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President New England Water Works Association,

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SOME NOTES ON TROPICAL WATER SUPPLY AND STUDY OF FILTRATION AT PANAMA.*

BY HERMAN K. HIGGINS.

DISCUSSION.

[*January 24, 1912.*]

MR. E. W. CLARKE † (*by letter*). This paper is of special interest to the writer as he was resident engineer on the Colon Water Works during most of the time referred to by Mr. Higgins.

The first part of Mr. Higgins's paper is evidently intended to be more interesting from a humorous standpoint than from an engineering one, but I think, in justice to those connected with the work, the impression which might have been left in the mind of any one reading this paper that the development of the supply for Cristobal and Colon was a haphazard operation should be corrected.

Colon was built by and because of the Panama Railroad, and while the writer has no personal knowledge of the early water supply at this city, as soon as the railroad shops were established, a supply was furnished to them from a small reservoir at Mt. Hope, and incidentally the inhabitants, who were mostly railroad people, were supplied with water during the dry season. During the balance of the year, — that is, from the middle of April to the end of December, — no artificial supply was necessary for drinking purposes, and such things as closets or baths did not exist outside of the houses of a very few of the higher officials. As Mr. Higgins states, water was at times brought from the Frijoles River for drinking purposes only, and supplied to the people at the water stations, one of which is shown on Plate III of Mr. Higgins's paper.

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* JOURNAL N. E. W. W. A., Vol. 25, p. 454.

† Division Engineer, New York Board of Water Supply.

The Panama Railroad Company had at least two sources of supply during the years previous to 1900, both of which were extremely small, but were sufficient to serve their purposes, and they never pretended to supply the city of Colon with water. The water stations were maintained for the use of their own employees during the dry season, who received water free, and for non-employees on the payment of a nominal fee.

After Cristobal was built, a water supply was obtained for a time from the west side of Limon Bay, as described by Mr. Higgins, from a stream draining a very small catchment area on the east side of the hills east of the Chagres River. Later, an infiltration well was sunk near Mt. Hope Station, — or Monkey Hill, as it was then called, — three standpipes holding about 30 000 gal. erected on a nearby hill, and a 4-in. main laid to Cristobal with a small distribution system in the town. No connections were made to the houses with the exception of two buildings locally known as "De Lesseps palaces," while the general inhabitants were served with one hydrant in each street. In the De Lesseps palaces, a limited number of faucets were placed, and two shower-baths. This system was not in operation when the United States took possession of the canal in May, 1904, but the resident engineer on the canal work at Cristobal repaired the pump at the well, and got the system into partial running order sometime in June of that year.

The writer arrived on the Isthmus in the latter part of July, and reconnoissances and surveys were begun for the location of an adequate supply of water for both Colon and Cristobal. The possible sources were four in number, and three were quickly eliminated for economic reasons. The fourth was on Brazos Brook about two miles east of Mt. Hope Station, and it was largely a matter of Hobson's choice that this brook was selected as a source of supply, as it was recognized from the beginning that the reservoir would be a shallow one, and that conditions would be ideal for the growth of algæ. A report on the subject with plans and recommendations as to details of work was made to my superior in December, 1904, and authorization to begin construction was received in March, 1905.

In December, 1904, I was instructed to take charge of the maintenance of the water supply for Cristobal, and as the infiltration well mentioned gave evidence that it would be unable to supply the demand, it was imperative that some quickly available substitute be found. About three quarters of a mile east of the railroad at Mt. Hope was the unfinished east diversion channel for the Chagres River, connecting at Mindi with the Mindi River, which in turn flowed into Limon Bay. The water in the channel during the wet season was fresh, and it was hoped that the volume was great enough so that it would remain at least suitable for boiler use during the dry season.

Two old French pumps were set up at the end of this channel, and a pipe line laid to connect with the standpipes mentioned as being part of the old French system. At this time, no cast-iron pipe had been delivered on the Isthmus, and this line was made up of old French pipe, both cast- and wrought-iron, from 2½ in. to 4 in. in diameter. As very few specials were to be found in the storehouse, changes from one size to another were made by pushing the smaller pipe into the larger, leading up the joint as well as possible, and placing concrete around it. The result of such construction was, of course, enormous friction. The static head was about 35 lb., but the pumps habitually ran under pressure of 65 to 70 lb., and as they were not designed to work under such pressures, the leather valves were continually giving out.

In spite of this, we managed to pump about 30 000 gal. per day into the standpipes. This was largely due to the patience and efficiency of the white machinist in charge of the pumps, who lived in a shack within a stone's throw of the station, and was up at all hours of the day and night endeavoring to make up for the inefficiency of the plant with which he was working. His assistants were Jamaica negroes, who were usually extremely ignorant and careless, and twice, during the operation of these pumps, crown sheets were burned out, necessitating the replacement of the boiler.

The pumps were not the only source of trouble in operating the system. Leaks were of weekly occurrence in the pipe line, and one valve had an annoying habit of closing from its own weight on account of the thread being stripped from the stem. The "very short, very fat, very profane" man, spoken of by Mr. Higgins, spent most of his waking time keeping this line in service.

As Mr. Higgins states, a distribution system was laid through Cristobal, and early in 1905 practically all the houses were provided with showers and water-closets, which was a decided improvement over the condition six months previous, when there were two shower-baths in town and water-closets were unknown.

By the 1st of April, the water in the diversion canal became brackish and finally practically salt water, so it was used only for flushing purposes. For drinking purposes during the early part of the dry season, dependence was placed on the rain-water barrels, which had been screened by the sanitary division, and as these barrels were generally in places easily accessible to any one, the consequence was that the negroes took water from any tank they saw fit, and by the 1st of February the supply was practically exhausted. Recourse was had to six reserved rain-water tanks having a combined capacity of 65 000 gal., and while an effort was made to restrict the use of this water to drinking exclusively, and daily permits were issued for this purpose, doubtless a considerable portion was used for washing. This tank supply finally failed, and water was then hauled from Frijoles by the railroad for a period of two or three weeks, and pumped into tanks, as shown by Plate I of Mr. Higgins's paper, which is a view probably taken in April, 1906, in the easterly part of Cristobal.

In May or June, pipe began to arrive from the United States for use in the Panama system, and sufficient 6-in. pipe was diverted to relay the line from the diversion canal to the tanks, and also to repair the 4-in. line. The pressure on the pumps promptly dropped to about 40 lb., and our pump troubles were over. Previous to this, a small dam had been built near the pumps, which collected water from a small drainage area, and the heavy rains of the latter part of May filled the pond, and gave fresh water for use at Cristobal.

It was realized that it would be impossible to construct the main dam, outlined in the report on the Colon Water Works, in time for use during the dry season of 1905-6, and, therefore, the temporary dam at the upper end of the watershed was constructed during the summer of 1905. Here again, we were working under most adverse circumstances, due principally to lack of material. For instance, in order to control the water during the placement of the embankment, a 4-ft. flume was designed to pass through the dam, and as it was impossible to get any dimension lumber on the Isthmus at that time, it was built up of four layers of 1-in. tongued and grooved California redwood, nailed together on forms, giving practically a circular section, and reinforced with telegraph wire, clinched up by means of home-made contrivances around the outside. This makeshift naturally enough gave trouble, and before the dam was entirely finished, we were forced to place posts nearly its entire length to prevent its crushing.

The site of the temporary dam was nearly a mile from the end of the narrow gage railroad to the main dam, and neither time nor number of men permitted the construction of a roadbed capable of supporting even our three-ton locomotives, so a line on which cars were pushed by hand was laid, and over this was hauled such material as we were absolutely forced to import for the construction of the dam. The cost of transporting coal prevented the use of steam for pumping, and an old hand fire engine, which we found at Cristobal, was put into service at the dam, and pumped water to puddle the bank. This dam was finished in time to collect the rainfall during October and November, 1905, but the abutting hills and the foundations proved so very pervious that a very considerable leakage occurred, and a secondary dam was built a few hundred feet down stream. The 8-in. spiral riveted pipe line passed through this latter dam, and towards the end of the 1905–6 dry season, the leakage from the upper dam was admitted into the pipe at this point, so that while, as Mr. Higgins states, the water in the upper reservoir was below the outlet of the pipe, a large proportion of it was eventually caught and used at the lower dam. In the meantime, the 20-in. pipe line from the main reservoir for Colon had been laid as far as the diversion channel, a connection made with the pump at this point, and Cristobal was supplied from Brazos Brook-shed during January and February, 1906. When this supply finally gave out, recourse was had to the diversion canal, salt water was again pumped into the mains, and tank cars brought fresh water down from Frijoles. The writer left the Isthmus in May of 1906, and has no personal knowledge of later conditions.

The only claim which the work done by the Municipal Division on the Isthmus during 1904–6 has for recognition by the profession is in the difficulties under which it was accomplished.

Fortunately, the *morale* of the engineering force was most excellent, and every one of the men did the best he could to make the work a success, and it was owing to this attitude on the part of the members of the force that in spite of difficulties due to lack of material and of labor that the first two years of the American occupation of the Isthmus saw the completion of the design and construction of water works and sewer systems for practically every town on the Isthmus and also for the cities of Colon and Panama. The men put up with discomforts and inconveniences of which later arrivals on the Isthmus had very little idea, and while the experience can be laughed at as we look back upon it, it was anything but laughable at the time; and the work done, while doubtless having many defects, was the result of a great deal of hard work and ingenuity on the part of every member of the Municipal Division. What has been said of the work at Colon and Cristobal applies with equal force to the work done at all the towns across the Isthmus.

THE RELATIVE CORROSION OF IRON AND STEEL PIPE AS FOUND IN SERVICE. [ABSTRACT.]

BY WILLIAM H. WALKER, PH.D., PROFESSOR OF INDUSTRIAL CHEMISTRY AND DIRECTOR OF THE RESEARCH LABORATORY OF APPLIED CHEMISTRY, MASS. INSTITUTE OF TECHNOLOGY.

[Read December 13, 1911.]

There are few subjects relating to the corrosion of metals which have received so much attention, or around which there has centered so spirited a discussion, as the relative merits of iron (meaning thereby wrought iron) and steel. The fact that this matter is one still receiving attention, notwithstanding the great volume of accumulated and available literature, is due to a number of causes, among which may be mentioned; — first, that although the words "iron" and "steel" carry with them a definite idea as to general methods of manufacture and some of the more easily discernible properties, they convey no idea as to standards of value. It is possible to make very poor iron and very good steel, and it is just as possible to make the reverse. Hence, when an investigator compared the corrosion of a poor iron with a good steel, he obtained results which favored steel; when the material under study was the reverse, iron was shown to be the more resistant metal. Second, there is a woeful lack of uniformity of conditions obtaining in many if not most of the experiments which have been carried on for the purpose of comparing resistance to corrosion. Some specimens were large, some small; some cleaned of scale, others not; some immersed in deep water, others in shallow water, etc. The corrosion of iron is so sensitive to changing conditions of surface, oxygen concentration, salts in solution, and the like, that only when the most careful preparation is made to maintain all conditions constant, is a comparative test of value. We will not discuss these conditions here, but take pleasure in referring the reader to that most excellent book, "The Corrosion of Iron and Steel," by Dr. J. Newton Friend, where a complete treatment of the general subject will be found. Third, many times opinions are formed and expressed by the casual observer which fail to take into consideration not only the fundamental conditions necessary to accurate comparative work, but also less obvious conditions which make a comparison unreliable. For example, a person may notice the rapid rusting of a cheap grade of steel wire fencing which had originally but a wash of zinc as a substitute for galvanizing, and thus become suspicious of the durability of all steel. Or he may notice holes in a metal roof put up in place of a material known to have lasted a much longer time than the new roof. He concludes that the later is of less value without having any knowledge of the change of conditions in the locality, class of metal, and the thickness of the new roof, nature and thickness of the galvanizing or other protective coating, and so forth.

Owing to the proverbial conservatism of New England, the introduction of steel pipe has been slower in this territory than in other parts of the country. There is a tendency to pronounce any pipe which withstands corrosion as being wrought iron, while the fact that a pipe corrodes easily is considered by many proof in itself that it is steel.

To determine what the facts actually are in regard to the relative life of service pipes which have been in constant use for a considerable number of years throughout New England, an investigation was undertaken in which it was proposed to seek out instances where steel and iron pipe had been used together in the same system; and further, where the two kinds of metal were separated in this system only by a coupling. Any influence which the coupling might have would be present equally with the iron and with the steel, while conditions of oxygen concentration, temperature, pressure, flow of water or steam, etc., would be as nearly identical for the two kinds of metal as it is possible to obtain. It was intended also to collect in this way material of known resistance or tendency to corrosion, in order to further test the applicability or truthfulness of the so-called " acid corrosion test." While the majority of the pipe so obtained was from hot and cold water feed systems, enough were selected from live and exhaust steam lines, hot-water and steam-heating systems, etc., to make the conclusions drawn of general application. The investigation was necessarily tedious in that each pipe had to be examined to determine whether it was of iron or steel, and many instances were found that would have served our purpose well, but where it was impossible to remove the pipes from the system. The pipes were sent to the laboratory where they were each split lengthwise into halves, and carefully cleaned from scale and rust by soaking in an ammonium citrate solution, with an occasional brushing. In this way the scale and rust were removed without dissolving any of the iron. An estimation of the extent of corrosion was made by measuring with a micrometer gage the ten deepest pits per unit distance of length.

The results are a splendid vindication of the principle that if oxygen be excluded or taken from water, no corrosion will take place. When the water in the lines examined was stagnant, as in fire-sprinkler systems for buildings, or in lines where the water was circulated over and over again without exposure to the air, as in some hot-water heating systems, no corrosion was to be observed. On the other hand, where fresh water was constantly added to the system, and heated within the system, corrosion was very rapid and in some cases excessive.

We were able to get sixty-four comparisons of iron and steel where the history of the installation was known. The results are as follows:

Comparisons where iron was found more corroded than steel,	20
Comparisons where steel was found more corroded than iron,	18
Comparisons where steel and iron were equally corroded,	9
Comparisons where corrosion was negligible,	17

These results again demonstrate that taken *on the average* there is no difference in the corrosion of iron and steel pipe. Conversations held with the engineers in charge of plants during this investigation confirm the statement already made that a pipe is frequently called steel when corrosion is found to be excessive, while it is set down as iron if it rusts but little.

In order to get some measurement of the influence of oxygen in the water of the modern hot-water supply system, a relatively large scale experiment was carried on at the plant of the Walworth Manufacturing Company in South Boston. Two coils made up from pieces taken from the same length of pipe were each fed with water from the same source at the same temperature. In one case the water was heated to 85 degrees cent. in an *open tank,* while in the other the water was heated to the same temperature in a *closed* tank. The feed water contained on the average 5.85 cc. of oxygen per liter, and passed through each coil at the rate of one-half gallon per minute. After running 1 750 hours the coil fed with water heated in an open tank had lost 22 gm., while the coil fed with water heated in a closed tank had lost 155 gm. In neither case was the oxygen completely removed; if the water in the open tank had been gently *boiled,* corrosion in the coil fed with this water would have been entirely prevented.

In order to show what relation may exist between the so-called acid corrosion test and the real corrosion as found in service, eleven pairs of iron and steel were selected and subjected to 20 per cent. sulphuric acid for four hours at room temperature. Four pairs were selected in which the steel was decidedly better than the iron in service, four in which the iron had shown decidedly better than the steel, and three in which there was no difference between the two metals.

In six instances the relative corrosion as shown by the sulphuric-acid test corresponded with the corrosion as found in service. In five instances corrosion as shown by the acid test was exactly contrary to that found in service. Although the greatest care was taken to have the specimens of the same size, cleaned in the same way, and in the same physical condition, the results show that no reliance can be placed in this accelerated acid test, but that it may be entirely erroneous and very misleading. Not only did the acid test not agree with the service test when steel was compared with iron, but the steels failed to agree among themselves, and the irons showed no agreement when considered by themselves.

DISCUSSION.

THE PRESIDENT. It was known long ago that pipes rusted, corroded, and in time had to be replaced. But when pipes are corroded there is action and reaction; the pipe is destroyed and the water also is affected. Some of the iron goes into solution in the water, and afterward, when the water is drawn, the iron separates and makes the red-water trouble we have heard so much about.

Now, my friends the pipe men tell me that if we will only give them a decent water to put through the pipes, the pipes will be all right, and some of the superintendents say that, if we only had decent pipes to send the water through, the water would be all right. There is probably some truth on both sides, and we want to find out to-day as much about it as we can, and see what kind of treatment will clean up this red-water trouble. We have heard from Professor Walker of the Institute of Technology, who has been studying this subject most carefully for several years, and have discovered a new point of view as to the quality of water. We are to consider it from the standpoint of the pipe. We have learned that a good water, from the standpoint of the pipe, is one that does not carry oxygen, that does carry plenty of organic matter, and that is also hard.

Now, gentlemen, that is not the standard we have been working for from the standpoint of the consumer. Perhaps we have been looking at it from a wrong point of view. We have been trying to give the people water which was good for them, but perhaps we shall have to turn about and give the pipe water that is good for the pipe.

Mr. Speller represents a company which, a few years ago, was a very large, perhaps the largest, manufacturer of wrought-iron pipe in the country, and his company has now given up making wrought-iron pipe and is making only steel pipe. I am going to call upon him to say what he can for himself, and justify his course if he can. And in doing this, I want him to bear in mind that this is not altogether a question between steel pipe and wrought-iron pipe; it is not a question whether he can get the wrought-iron business for the steel pipe, but it is a question whether either steel pipe or wrought-iron pipe is going to answer the requirements of the members of this Association for the water which they supply to their consumers.

MR. F. N. SPELLER.[*] *Mr. President and Gentlemen,* — From what has just been said I judge you are aware that we have followed this question as between wrought iron and steel pretty closely, and that we have been particularly interested, especially during the past six or eight years, in the matter of durability. Naturally so, because most of our product cannot usually be protected by coatings, and therefore it becomes very important to make it as durable as possible in the natural state. Our work has been very largely furthered by the researches of such scientific investigators as Professor Walker. They have laid the foundation on which we, who have less time to go deep into fundamental principles, have worked.

---

[*] Metallurgical Engineer, Pittsburg, Pa.

Dr. Walker's work has been so extensive in New England as to be practically conclusive as regards pipe in that district; but it may be just as well to give the results of similar investigations in other localities which Dr. Walker's researches closely corroborate in order to broaden out the scope of our conclusions.

We have records of four similar investigations (Table 1, page 17) made on pipe in water lines where wrought iron and steel were used together; I do not know why they were put in together, but there they were so found. More than likely it was simply accidental.

In the first place, you will find in the *Engineering News* of December, 1910, a report on the condition of the hot-water lines in the New York City bath houses, made by Prof. Ira Woolson for the city of New York. Eighty-nine samples were secured, seventeen of which were wrought iron. The corrosion was reported as practically equal.

The next one we come to is an investigation made in the boiler feed-water lines of the Frick Coke Company, at Scotdale, Pa. Here we have an entirely different class of water in a different locality. The relative corrosion there was found to be 100 in the case of wrought iron as against 99 in the case of steel. The average depth of the pitting in 21 lots, including the wrought iron and steel samples, was .112 of an inch in the wrought iron and .108 in the steel. In all these investigations there was found for the same length of exposure a very considerable difference between one sample and another, as much as 25 per cent. one way or the other, but on averaging up a sufficient number of samples in the same system, or in different systems, and making comparison, the results come out almost exactly the same, as Dr. Walker has found in New England.

Another investigation was made in the Cresson coal fields, with water of various characters, and leads to the same conclusion, viz., — 100 for the wrought iron as against 99 for the steel.

Later still, in the past summer, it happened that the hot-water supply lines gave out in the Allegheny General Hospital. This pipe was put in seven or eight years ago and it was decided to remove the entire system. This offered a splendid opportunity, and by arrangement with the architects we put one of our research men on the plant with instructions to take a sample from each length of pipe as it was taken out, leaving a portion of each length with the architects for independent examination. Out of 69 samples taken from the hot-water system, 42 were wrought iron and 27 turned out to be steel. The average depth of pitting in the wrought iron was .092 of an inch and in the steel .094, — practically the same again.

So we have, including Dr. Walker's research, over 150 cases where a true comparison between iron and steel pipe is possible.

So many factors are introduced in corrosion where the metals are exposed to the atmosphere or underground that it becomes very difficult to make a comparison, and no comparison can be safely made unless both materials are put into service at the same time and in such a way as to leave no doubt as to the environment being practically the same. The conditions which obtain inside a water line as in the cases cited we can agree, I think, meet the requirements of a perfect comparison as near as can be, for here we have the two materials coupled together and carrying the same water both as to quality, quantity, and temperature.

We have made galvanic tests of wrought iron and steel to learn if there was any difference of potential and find a slight difference, but not always in the same direction, for sometimes the wrought iron and at other times the steel will be the anode. Moreover, the current tends to reverse itself as corrosion proceeds, the anode because of the hydrated oxide which collects on its surface becoming the cathode. In any case the current caused by contact is so exceedingly weak as not to influence the corrosion of the metal more than a small fraction of an inch away from the contact, and all comparisons as to pitting in the tests referred to were taken at a safe distance from the joint.

The results of these experiments also indicate the error of the claim that absence of manganese * and the presence of considerable cinder † are controlling factors in lessening corrosion. Mill scale which forms on the surface of iron and steel on cooling in the air has the strongest potential difference of all the materials which are likely to be found in or in contact with iron and is the most frequent cause of pitting. Mill cinder which is formed in irregular patches and strings in puddled iron has about the same difference of potential, and, being decidedly electro-negative to iron, greatly accelerates the solution of the metal. There may be something in the claim of the mechanical protection from cinder, for it is a good protector when the entire surface of the metal is covered, but this protection becomes worse than useless when the cinder is in exposed contact with the iron, as it then causes corrosion to proceed at irregular and greatly accelerated rates on the exposed surface, which results in the familiar phenomena known as pitting.

Another instance where a true comparison may be drawn might be here referred to (and many more could be added), since it indicates that the general conclusion we are forced to regarding pipe materials is not restricted to water lines. About thirteen years ago in the Ohio and Indiana oil field some operators started to use steel casing for the wells and it later came to be used exclusively by these companies, but for a few years wrought iron and steel were kept in stock and put in together, as it frequently happened, in the same well. By examining a number of strings of casing recently pulled which date back to this period, cases were found where the iron and steel were screwed together, and invariably where one is affected the other is damaged to practically the same degree. The same may be said of the couplings which have always been made of iron, an example of which is shown in Plate I. So far, then, as the steel pipe made during the past twelve years or so is concerned, there appears to be little to choose between it and the wrought iron of the same period. It might be inferred from

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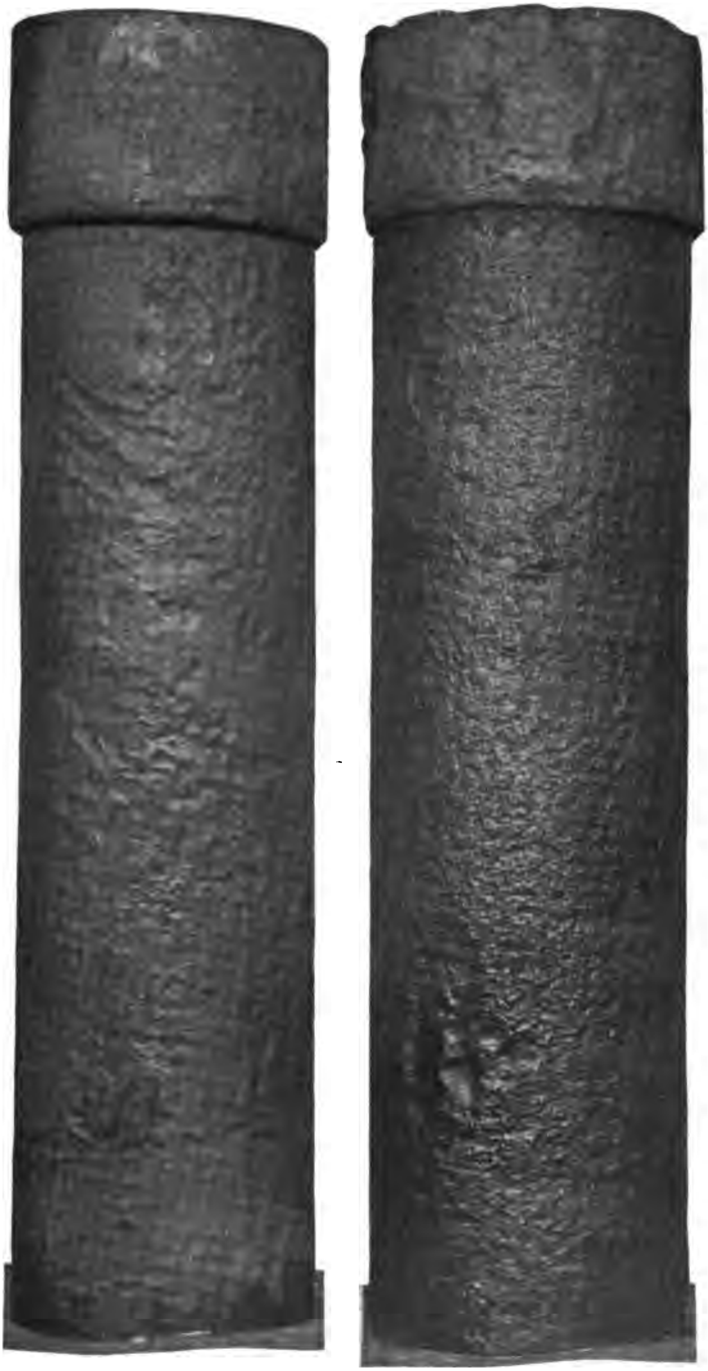
* An investigation described in *Journal of Iron and Steel Institute*, Vol. LXXXIII, p. 189, 1911, indicates that manganese compounds tend to protect iron from corrosion.

† See p. 172 (*Ibid.*) as to the influence of cinder and mill scale.



COMPARISON OF STEEL PIPE AND IRON COUPLINGS FROM INDIANA OIL FIELDS, AFTER 15 YEARS' SERVICE.

MroU

this experience that since some of the factors controlling corrosion have been better understood and steel has been made with due regard to its durability in the light of the late scientific study of corrosion, that modern steel so made is superior to wrought iron, and tests under way indicate this to be the case, although non-corrodible iron has yet to be discovered.

How, then, some of you will ask, can we explain certain experiences which have been cherished almost as trade marks by some of our friends who still claim to be manufacturing wrought-iron pipe? It has been found in a few isolated cases that wrought-iron pipe made before steel pipe was thought of has outlasted steel put to the same use many years after. It is hardly likely that the wrought iron made in the early days of pipe manufacture was so much better or the steel so much worse than nowadays, although this may in some measure account for such cases. It seems more probable that the early history of the treatment of the surface of these old pipe in or after manufacture, whereby it acquired some effective protection, will account for such cases of extraordinary resistance to corrosion. The strong resisting qualities of a silicious iron scale formed in manufacture or the natural scale formed and dried on the surface by years of exposure under mild conditions of intermittent corrosion may afford the necessary permanent protection, if indeed it was not after all due to a forgotten coat of good paint, for the early history of these isolated cases cannot be said to be known with any degree of certainty. In a study of the corrosion of metal on the Panama Canal two years ago, we found several cases of this kind in looking over some old French junk — of course, as in other instances, these pieces of apparently unprotected pipe were conspicuous by their rarity, most of this material not so fortunate having dissolved and disappeared. Some of these pipes which showed no evidence of paint, but which had a thin, hard, badly weathered scale, were threaded for a foot or two and hung up to the moist breeze on the Pacific coast with some pieces of new steel pipe of about the same thickness, which, of course, were similarly treated. In six months they were both badly and equally corroded and the old iron was found to have lost more in this time than in the previous twenty-five years.

The apparent inconsistency between the facts as found in these investigations and the opinions quite generally held as to the superiority of wrought iron is not difficult to understand when we consider —

1. How few who hold to this opinion base it on anything more than what they have heard others talk of, whose experience frequently amounts to nothing but general observation or inference from results of what they have seen with iron or steel products other than pipe, from which it is unfair and misleading to draw comparison.

Confusion of opinion has resulted from treating the question of corrosion too generally. We cannot compare all kinds of steel as a class with all sorts of wrought iron. We are just beginning to learn that well-made sound steel is not only as durable as the best wrought iron on record, but for special conditions, for example, where acid conditions prevail, steel may be made so as to be many times more resistant than iron.

2. From the demonstrated fact that the majority of those handling pipe day by day are half the time unable to tell wrought iron from steel.

3. That corrosion conditions are generally much more severe nowadays and have become more so, much in the same ratio as the relative proportion of steel pipe has increased, so that it would only be natural to connect the more general use of steel with the observed decrease in useful service of pipe in certain localities.

4. The important influence of the man who handles the pipe, who not infrequently prefers wrought iron as being somewhat easier to thread with the average die and because it is a union-made product as against steel made in non-union mills.

All these and other influences which have been used to fan and keep alive a prejudice, steel pipe has had to contend with and live down.

The President. Gentlemen, there seems to be no doubt but what many samples of wrought-iron pipe in the old days lasted much better than the pipe which has been put in recently, and Mr. Speller, I see, goes back to the idea that perhaps the water that they had in the old days was better for the pipe than the water that we have now. I expect that was often the case, because it seems to be generally true that the cleaner the water, the harder

TABLE 1.

CASES OF COMPARISON OF WROUGHT IRON AND STEEL UNDER INTERNAL CORROSION IN WARM WATER SUPPLY LINES.

Summary of Results of Investigations on Record during the Past Two Years.

Locality.	Number of Cases on Record.	Average of Deepest Pits.		Reference for Details. Remarks.
		W. I.	Steel.	
New York City Bathhouses.	89 samples secured, of which 17 were wrought iron.	Equal 100	100%	*Engineering News*, Dec. 3, 1910, p. 630; or N.T.C. Bulletin No.2. Conditions were those of actual service and pipe was tested to destruction.
Frick Coke Co. Power Plants	21 lots, comprising 52 samples, of which 26 were wrought iron and 26 steel.	.112 in. 100% 100%	.108 in. 96% * 99% †	*Engineering Review*, April, 1911; or N.T.C. Bulletin No. 3; or Amer. Soc. Heating & Ventilating Engrs., 1911. Conditions were those of actual service, varying from 6 months to 7½–8 years.
Cresson Coal Fields	20 samples, of which 10 were iron and 10 wrought steel.	.094 in. 100%	.093 in. 99% ‡	Preliminary report of J. J. Wilson, Aug. 29, 1911. Conditions those of actual service, varying from 6 months to 10 years.
Allegheny General Hospital	81 samples, of which 69 are from the hot-water lines, 42 wrought iron and 27 steel.	.105 in. 100% .092 in.	.105 in. 100% * .094 in. †	Preliminary report of D. R. Mason, Dec. 8, 1911. Conditions those of actual service; pipe was tested to destruction.

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* Depth of deepest pit in wrought-iron samples taken as 100 per cent.

† Average depth of five deepest pits in wrought-iron samples taken as 100 per cent.

‡ Average depth of four deepest pits in wrought-iron samples taken as 100 per cent.

it is for the pipe. That is a feature of the situation which must be taken into account. At the same time we find that in many important enterprises, where people are studying the conditions very carefully, they think they had rather have wrought-iron pipe, and they are willing to pay a substantial increase in price in order to get it. We want to know whether this is prejudice or whether there is some foundation for the preference. We are fortunate in having with us to-day Mr. George Schuhmann, the vice-president and general manager of the Reading Iron Company, one of the largest, perhaps the largest, manufacturers of wrought-iron pipe in the United States. I have great pleasure in introducing Mr. Schuhmann.

GEORGE SCHUHMANN, ESQ. *Mr. President and Gentlemen,* — In order to make my arguments clear to you, I may have to bore you a little at first with a description of the manufacture of wrought iron.

Mr. Speller mentioned that iron made many years ago was probably made better than iron is made nowadays. In reply to this I wish to state that we make our wrought iron to-day in exactly the same way as it was made in the olden times after puddling was invented; that is, we puddle our iron from pig iron. As no doubt many of you know, pig iron is a cast iron, containing about 93 per cent. of pure iron. The rest is carbon, silicon, phosphorus, sulphur, etc. This pig iron is remelted in the puddling furnace (the fire chamber being separated from the melting chamber), the temperature in which is above the melting point of pig iron but below the melting point of wrought iron, and when the metal is in a molten state it is stirred up by the puddler and his helper, which causes the carbon in the iron to burn out, and as the particles of iron become purified, they partly congeal, *come to nature,* because the temperature of the furnace is not high enough to keep the pure iron liquid. The other impurities will separate from the iron, forming puddle cinder, in which the pure iron crystals float around, like sugar crystals in molasses in a vacuum pan. As more and more of these crystals congeal and come in contact with each other, they stick together, forming a spongy mass, the cavities of which are filled with liquid cinder, or, to make a homely comparison, it is like a popcorn ball, held together with molasses.

After removal from the furnace, this spongy mass is squeezed or hammered into blocks and then rolled out into bars. The cinder-coated globules of iron become elongated, giving wrought iron a fibrous structure, that is, the iron and the cinder coating get stretched out together, so that the latter is distributed through the whole body of the iron. This enclosed cinder plays a most important part in the resistance against corrosion. It consists of a silicate of iron, — an iron oxide with some silica; and because silicate of iron resists ordinary corrosive action better than pure iron, its presence in wrought iron is responsible for the fact that wrought iron resists corrosion better than steel, because the latter is a more homogeneous metal, without any enclosed cinder fibers.

Mr. Speller mentioned something about old wrought-iron pipe in use on the Panama Canal, which presumably had been furnished by the French many years ago, and which was still in good state of preservation, and he further stated that the pipe had probably been painted. Now, if a layer of paint can prolong the life of iron and steel, a fine layer or fibers of silicate of iron all through the body of the iron is also a resistance against corrosion, but, like most paint, it is only a resistance against mild corrosive influences, for if we pour acid on the paint we destroy its usefulness, and so it is with the protection afforded by the cinder in wrought iron. To illustrate this roughly, you can take several layers of blotting paper held tightly together with rubber bands. At one end between each layer of blotting paper place a layer of thin writing paper, to represent the cinder, while at the other end there is only the blotting paper, to represent the steel; or, to use the analogy of the popcorn ball, the blotting paper represents the corn and the writing paper the molasses. Now, if we pour an equal quantity of ink on the end representing the steel, the ink will penetrate several layers of the blotting paper, while at the other end the first layer of writing paper has practically arrested the penetration of the ink. If we take acid instead of ink, it is a different story, as the acid will go right through the writing paper as well as the blotting paper.

I am very much pleased to hear Professor Walker confirm our contention that acid tests are entirely unreliable as a guide to resistance against ordinary corrosion. It gives me great satisfaction to say this, because, when I made the same statement some years ago at a meeting of the American Society for Testing Materials, some scientific gentlemen present disputed it. I believe, however, that those who have followed the discussion of this subject are now agreed that the accelerated corrosion tests are entirely unreliable and misleading.

While the protective action of the cinder fibers has been admitted, some scientific gentlemen have argued that there was not a sufficient amount of cinder in wrought iron. They had some microphotographs of wrought iron magnified seventeen diameters which showed only a few patches of cinder here and there; so they claimed this was like a picket fence that would let the wind (corrosion) blow through. Photographs magnified fifty, one hundred, and two hundred diameters, however, show that the picket fence has the pickets pretty close together.

Unfortunately, there have been some irons put on the market that are made by using old junk-yard scrap, heated up to a welding heat, *busheling or fagoting*, and then rolled out into bars, sheets, etc. When the old scrap consisted of nothing but wrought iron, it was not so bad, because wrought iron is permeated with the cinder fibers which were produced in the puddling operation, but junk-yard scrap nowadays is mixed with more or less steel, some of it, may be, high carbon or other alloy steel of various grades, and since steel is not permeated with cinder fibers, when these pieces get rolled into the iron, you have a starting point for corrosion or pitting. We fear that some of this kind of iron has been paraded as genuine wrought iron, and in some cases picked out when making comparisons with modern steel. Just as paint is a protection against corrosion on the outside of the metal, so the cinder fibers permeating wrought iron are a protection in the interior of the metal. In other words, a wrought-iron bar is like a wire rope of which every individual wire was painted before the rope was put together. The wires are the iron fibers and the paint is represented by the cinder fibers. Inasmuch as the method of making wrought iron by the puddling process is still the same as in vogue fifty or seventy-five years ago when puddling was first invented, and all the wrought iron used in our pipe is made that way, I do not see why it should not be just as resistant against corrosion as the iron which was made many years ago.

The President. I am sure we have been very glad to hear how wrought-iron pipe is made, described in a way so graphic that we can all understand; and I am sure we are glad to know that it is made in the same way that it used to be made in the good old days. Mention has been made of the fact that users often do not know whether they are using wrought-iron pipe or steel pipe. Some of our members feel that there ought to be a way of marking pipe so that the mark could not be changed, and so that every user who knew the marks could see and know certainly what mill the pipe came from. I think it would be interesting if Mr. Schuhmann and Mr. Speller would tell us before they go whether they are willing to mark their pipe so that everybody will know when they get it, and if not, why not?

We have been hearing recently about a new kind of iron, not quite a steel, although made something like steel. Is there any one present to speak for this new product which has recently come upon the market?

Mr. H. S. Kahurl. Mr. President, we expected to have here to-day a representative of the Harrisburg Rolling Mills Company of Harrisburg, who is interested in this pipe; but unfortunately he was detained in New York. I cannot personally say anything in regard to the qualities of this pipe, except that it is a new product that we have taken over and are going to sell in New England. Whether the sulphuric acid test which is spoken of is any good or not, I cannot say definitely. All I can say is that the American Rolling Mills Company of Middletown are putting out extensive advertising with the sulphuric acid test shown up on a little blue print. I can also say that a number of leading engineers of the country have endorsed that test. I see that the manufacturers of steel and of iron fall back on the argument of the long time that wrought iron and steel have been in use. As ours is a new product, we cannot, of course, bring forward any samples that have been in the ground as long as theirs.

The President. Certainly it is nothing against a new product that it cannot show long experience. The subject is now open for general discussion and also for questions, because we have Mr. Schuhmann and Mr. Speller here especially so that you gentlemen may ask them all the questions you like.

MR. A. W. CUDDEBACK.* We do not use galvanized pipe any more; we have found it not satisfactory.

GEORGE SMITH, ESQ.† Mr. President, I am not a member of the Association, but I believe that Springfield was instrumental in getting this report from Professor Walker to-day. We had some serious trouble in Springfield with regard to water after our new supply was turned on to the city; and after the newspapers had complained of the plumbers and builders using poor material, we forwarded the report which referred to the use of steel pipe to the National Tube Company. Of course, we did not know whether it was using steel or wrought iron. We bought wrought iron sometimes and sometimes steel, but in each case we had the same trouble.

We also have the same trouble, I might say, wherever we use brass pipe. The red-water proposition is just the same. We have never been able to give the public of Springfield a satisfactory answer. A man comes into our place and asks us why he gets red water in his system, and we tell him so-and-so, but he does not believe us, simply because of the report, made, I believe, by Mr. Whipple, of the firm of Whipple & Hazen.

We would like to go back to Springfield with an answer from such a man as Professor Walker or Mr. Hazen or Mr. Speller, why we get red water in systems where we have brass pipe and copper boilers, just the same as we get it where we have iron and steel pipe and steel boilers. We asked the water department for help and they were very courteous in doing anything we asked them to do. They flushed the mains, getting out a great amount of substance which we had analyzed, and we also had analyzed the material which came from the service pipe and the boiler, and in each case it showed about ninety per cent. iron, according to Dr. Emerson, of Springfield, and about one half of one per cent. more from the service inside the building than outside.

The Springfield Master Plumbers Association is interested to have something to tell these people, when they come into their places of business, as to what causes the red water, and why we get it in systems where we have copper and brass pipe just the same as where we have iron pipe. Now, any information we can get on that point from Mr. Walker would be very welcome by us.

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* Engineer Passaic Water Company, Paterson, N. J.

† Of George Smith & Co., Springfield, Mass.

Professor Walker. Mr. Smith very kindly handed me a list of questions just before the meeting, and I will now do what I can to answer them.

The first question is: " How do you account for the great amount of red hard substance taken out of the street main? " If the red hard substance is by analysis 90 per cent. iron oxide it means that it is ordinary rust. The other parts are doubtless material from the water itself. We will leave this question and come back to it later, because it really takes in all the remaining questions.

" How do you account for this substance taken from the street main containing about the same amount of iron rust as the substance which is taken from the service pipe and storage tank inside the building? " I think the only answer to this is that the material is from the same source; the fact that one is found in one place and the other found in another place simply means that there is one common source, and the material is carried therefrom to both places. I do not believe there can be any answer to this other than the one that the material comes largely from the street main, and is carried mechanically by the water into the service pipes.

" How do you account for the red-water trouble in buildings where the houses are piped with either brass or lead pipe and the storage tanks are copper? " Of course, it goes without saying that you can't get iron rust, which this red material is, from a copper tank or lead pipe or brass pipe. That requires no discussion. So the answer to this question also is that the red water must come from the iron mains. In other words, the rust is formed in the mains and is carried through the mains into the house systems.

" How do you account for the sudden change in condition since we have been using Little River water? " I am ignorant of the properties of the Little River water, and I really cannot talk about it with authority because I haven't the data. I would say without much hesitation, however, that some of the factors that we have discussed here this afternoon have been intensified in the Little River water. I believe that this matter can be solved. I do not think that the city of Springfield should lie down and suffer from red water until they know what the cause of it is; but I am not prepared to say now what the cause may be, because I have never made a study of the conditions.

" Can you tell us why it is that steel and wrought-iron pipe can be used in the city of Holyoke, which is only eight miles from Springfield, while this same pipe cannot be used in Springfield? "

The answer to that is, of course, that the conditions which obtain in Springfield do not obtain in Holyoke therefore it must be possible to determine these conditions. I cannot now say what they are, but it must be possible to find out.

Now, coming back to the first question, " How do you account for the great amount of red hard substance taken out of the street main? " You account for it by some intensified condition of corrosion in the water. Assuming it to be true that Holyoke uses steel and iron pipe and the same water that Springfield does, and Holyoke is free from this trouble, while it is so intensified in Springfield, the trouble must be due to some difference in the local treatment or conditions. Just what these differences are can be determined only by an investigation.

Let me say, in reply to Mr. Hazen's remark, that apparently the only remedies which one can apply to water to save the pipe are those which kill the water; that it is a good deal like the old man who thought he could teach his horse to eat sawdust; the moment the horse got so he could eat sawdust, he died. You cannot put in lime, I realize that, however efficient that would be; and you cannot have too much organic matter, because you want pure water; but you can, if necessary, take the oxygen out.

I don't know whether you have followed the very important work that is being done in Australia, where there is a very expensive steel or iron aqueduct which is corroding badly. The reason why it corrodes badly is because they have such a very pure water. Mr. Hazen is right in saying that the purest water is the worst water on pipes. You will find in a boiler plant which being supplied with a spring water that is absolutely pure that the pitting and corrosion is enormous. We had a case of this kind from Cape Breton; the water used for the boiler plant was exceptionally pure and the boilers were pitting very badly. The trouble was that there was nothing in the water to coat the pipes over, that is, to make any boiler scale. The water was saturated with oxygen, and, therefore, corrosion was rapid. The difficulty was overcome entirely by putting in open pre-heaters where the oxygen was boiled out of the water before it went into the boilers. The trouble absolutely and entirely disappeared, as it must have, because without the oxygen you cannot get corrosion.

They are doing the same thing in Australia, namely, putting in an elaborate system to take the oxygen out of the water. I do not know that we can do that, except in apartment houses. I do believe it is possible there, and it may be the solution to which we will have to come. It will not spoil the water for drinking purposes. Taking the oxygen out is not in any way, so far as I know, and I think I am right in this, depleting the water of any of its valuable constituents.

MR. DEXTER BRACKETT.* The service pipes used in the cities and towns comprising the Metropolitan Water District are generally of lead, but wrought-iron pipes, both plain and galvanized and lined with cement and lead, have been and are still used. Lead service pipes have been almost universally used in Boston since the introduction of water from Lake Cochituate in 1848. Investigations made at that time showed that the action of Cochituate water on lead in a few days forms a coating which for all practical purposes is impervious to water, and that the water can be served from lead pipes connected with iron mains without detriment to health.

Regarding the life of wrought-iron pipes, it is well known that pipes made of thin sheets of wrought iron, lined and covered with cement, were extensively used in distribution systems in this vicinity from forty to fifty years ago, and also that in most cases these pipes failed after from fifteen to twenty-five years' use and have been replaced by pipes of cast iron. There are, however, instances where the work was well done, and the pipe was not tapped for house services, in which the life of this pipe was much prolonged.

There is in use on the Metropolitan Works a 30-in. wrought-iron cement-lined main about two miles in length which has been in constant service for forty years and is still apparently in good condition.

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* Chief Engineer, Metropolitan Water Works, Boston.

The speaker has in his office a section of pipe 5 in. in interior diameter, bored through a wooden log, which was laid by the Jamaica Pond Aqueduct Company about one hundred and ten years ago and was used for at least fifty years for conveying water to the city of Boston from Jamaica Pond. The large end of this log or pipe is encircled by a wrought-iron ring 10 in. in diameter, 1½ in. wide, ¼ in. thick on one side and brought to a sharp edge on the other. This ring, which was buried in the ground and exposed to moisture for one hundred years, is, so far as can be judged, in substantially as good condition as on the day it was made. It appears very doubtful whether it would be in its present condition if made of steel.

An example of the preservation of wrought iron, which the speaker attributes to the cutting off of the supply of oxygen, is the perfect condition of wrought-iron bolts in a submerged pipe line after having been buried for fifty years under the mud bottom of Boston Harbor.

The President. There is sometimes trouble in the use of lead pipe, I understand, in services. Will Mr. Thomas tell us what the conditions are in Lowell as regards his service pipes?

Mr. Robert J. Thomas. Mr. President, our trouble with lead pipes at Lowell has not been due to the lead, but to the clogging up of the pipe due to the water containing a large amount of crenothrix, unless you are referring to the time some years ago when we were warned that the water acting upon the pipe absorbed the lead so that lead poisoning was caused. That, of course, is simply following out what Dr. Walker said, that all these metals are more or less soluble in water, and the water in that case in Lowell acted upon the lead pipe. It also acts upon iron to some extent. We have used some galvanized pipe, but without any special advantage so far as we could notice in the results. The pipe which has given us the best results is tin-lined pipe. We have found by experiments that the water acts less upon tin than upon any of the other metals which we could use for pipe.

The President. What material do you generally use for service pipes now?

Mr. Thomas. It is a tin-lined iron pipe. That is, I presume it is iron pipe; it may be steel.

Mr. Edwin C. Brooks.* Mr. President, I might say in regard to steel pipe, that I find that the weld, where the pipe is butt-welded, is apt to be so hard that it is very severe on the dies, and we found it was hard to cut clean threads on many pieces of steel pipe on that account. I would like to ask Mr. Speller if it is possible that any hardening could take place in the butt-welding of steel pipe? We certainly have had a good deal of trouble from that cause, and we are now using wrought-iron pipe.

Mr. Speller. I think you will find the trouble — if there is any trouble with the threading — is on account of not having a good die. The steel is somewhat harder to thread than iron, but you will not notice it if the die is properly shaped. What you refer to as hardness at the weld may be a slight depression at the weld, which will cause the tooth of the die to catch. When you speak of hardness in steel pipe it usually means toughness.

Mr. Brooks. I have been too long in the business to have tools of the kind you suggest. What I speak of is hardness. The dies that we use are from a reputable firm in Boston. I think you would find it hard to maintain that their dies were not suitable. We found a hardness in the weld; that is, when you tried it with a file it would seem as if it had been actually tempered along the line of the weld. Now, whether anything occurred at that point to tend to harden the steel more than at another point, I do not know; but the trouble was certainly a real trouble and not a fancied one.

Mr. Speller. I have never had any experience with such cases as that, and when I was speaking a moment ago, I was referring to other instances that seemed to correspond with yours. This is the first time I have ever heard of a piece of pipe steel being what you would call hard at the weld. If it is genuine pipe steel it cannot be hard, or we could not weld it. It is one of the purest forms of iron made. It has no tempering quality whatever. You can forge it and chill it in water without hardening in the least. If you have any cases like that on hand we would certainly like to see them.

Mr. Brooks. We discontinued using steel for the very reason that there was so much complaint made of the hardness on this line running through lengthwise of the pipe, where the weld was; and it occurred to me whether there might be any possible reason for that in the manufacture.

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* Superintendent Water Works, Cambridge, Mass.

THE PRESIDENT. Perhaps that wasn't Mr. Speller's pipe, Mr. Brooks. If he had put his name on it you would have known with certainty.

MR. RICHARD A. HALE.* In connection with the water-power development at Lawrence in the earlier days, wrought iron was used as material for the penstocks, the diameters of which varied from 6 to 9 ft. In the last two or three years some changes were made, involving the installing of new wheels, and necessitating a cutting off of the lower portion of some of the penstock. In one mill there was a penstock,I think, 8 ft. in diameter, of wrought iron, which had been in for forty-five years, and an examination of it, where it was cut off, showed no deterioration of the iron that was visible in any way whatever. The iron was bright; there was no pitting. The penstock had been preserved by painting with red lead from time to time when the water was out. There was no pitting either on the inside or on the outside, and no reduction in thickness.

During the last twenty or twenty-five years steel plates have been used for penstocks instead of wrought iron, and observation from year to year of the surface of the interior has shown no indications of marked deterioration. In some cases, where the coating of asphalt has worn off, or whatever paint was put on, there have been some tubercles formed and a slight pitting, but not to any depth; the outside of the penstock does not show that any changes have occurred where it could be examined.

As far as we have seen, there has been no great difference between the steel and the wrought iron. The principal trouble with a steel penstock, and with all penstocks, is to find a proper coating to prevent the water from corroding the interior. Certainly wrought iron, after an experience of forty-five years, has been found to be in excellent condition.

Mr. Brackett speaking of the ring reminded me that recently we took out a wooden penstock, which had been in about fifty years, with iron bands on the outside about an inch and a half to two inches in width and half an inch in thickness, and the wrought iron shows excellent condition, with a bright and fibrous texture, although no coating had been put on. A chemical examination showed a very excellent grade of wrought iron. In all of these cases there were no electrical currents in the vicinity which would produce electrolysis.

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* Principal Assistant Engineer, Essex County, Lawrence, Mass.

Mr. William F. Sullivan.[*] Our experience with so-called galvanized wrought-iron pipe has shown that the average life of 1-in. pipe is from twenty to twenty-five years, and of ¾-in. pipe from fourteen to twenty years, — that is, before it fills so that the service has to be renewed. We find after the filled up pipe is placed in the "scrap" the matter that blocked the flow of water dries and can be knocked or shocked from the interior of the pipe by the aid of a scraper. The old pipe is generally in good condition and may be disposed of as second-hand pipe for about one quarter the cost of new pipe. The users of this second-hand pipe are generally farmers or campers.

We find that the cost of renewing services is inexpensive, owing to the low first cost of the pipe and the character of the excavation — in many instances we are able to drive new services without much trenching. We find that the galvanizing wears off the pipe in a few years, but we feel satisfied that it is worth the slight difference in cost to use galvanized iron pipe. We are not always absolutely certain whether we get the genuine wrought-iron or steel pipe, and as far as my experience goes, it never has seemed of great importance to us on account of the periodic filling up of service pipes.

Mr. George A. Stacy.[†] I have had about the same experience as that of Mr. Brooks with regard to temper in steel pipe. I don't know about the life of iron or steel, but I think that the dies will last longer on wrought-iron than they will on steel pipe.

The reason I have adopted wrought-iron pipe is because as a general thing when you go into the market you get heavier stock, you get stock that works easier, and it runs more even. We do find that some steel pipe, or pipe which comes to us as steel, is much harder and affects the die much more than wrought-iron pipe does. Of course, a dull die is not a very pleasant thing to work with when you want to cut a good thread on anything; but when you get a dull die on a piece of hard steel pipe you have a pretty tough proposition.

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[*] Superintendent Pennichuck Water Works, Nashua, N. H.

[†] Superintendent Water Works, Marlboro, Mass.

I don't condemn steel pipe; I don't know anything about the life of it; but if we have two pieces of pipe, and the pitting is equal, then the light pipe is going first.

Up to the present time my experience with wrought-iron pipe has been every way much more satisfactory than that with steel.

Mr. F. N. Connet. I have not had experience with steel pipe, Mr. President, but there is one question I would like to ask Professor Walker. Some years ago the New York Edison Company had considerable trouble from the depositing of a red material in their boiler feed system, and analysis proved it to be oxide of iron. They used surface condensers, and consequently the same water was used over and over again and no additional oxygen could get into the system. They had been using a small percentage of animal oil in their lubricating oil, and they decided to change over and use mineral oil entirely, after which this trouble ceased.

The explanation which was offered was that a catalytic action had taken place due to the oleic acid present in the animal oil. The idea is that a certain amount of oxygen was absorbed by the oleic acid from the oxide of iron and this was afterward released so that it could immediately combine with more iron and be converted again into oxide of iron, which process could be repeated indefinitely without the necessity of constant renewal of oxygen from outside.

Whether or not this explanation is the correct one, it is certain that when the use of animal oil was discontinued the trouble disappeared. Their feed pipes were four or five inches in diameter and some were the cast iron, some wrought iron, and some cast steel.

Professor Walker. With regard to the word "catalytic," I think that engineer was probably doing as a good many of us do, — when we strike something we don't understand we call it "catalytic action." I don't think it was catalytic action; nor do I think oxide of iron will give up its oxygen when once formed. On any steam heating system which has been running in a closed cycle for a good while, when you open a radiator pet cock not infrequently you will get enough hydrogen to burn. That is due to the presence of carbonic acid gas in the system. This gas passes up with the steam and is absorbed by the condensed water, forming an acid solution. This reacts on the iron pipe, forming soluble iron carbonate. This returns to the boiler and under the heat there decomposes into iron oxide and sets free carbon dioxide again. I have never heard of, nor do I believe you can have, a cycle in which oxygen acts in this way; when oxygen is taken up by iron it stays combined.

I think it is a fact without question that the animal oil does form free acid when heated with water to a high temperature, and this in itself accelerates corrosion.

Didn't they use any makeup water at all?

MR. CONNET. A very slight percentage.

PROFESSOR WALKER. A possible explanation is, I think, that they were taking some air into their vacuum system. If you are getting an accumulation of iron oxide it means you are getting additional oxygen. There is no possible escape from that conclusion. Where that oxygen is coming from may be a question. But if they use no makeup water and if their system is closed, that is, if they have no expansion tank, my suggestion would be to look for an air leakage somewhere; because if you use up the oxygen in uniting with the iron at one place, I don't believe that this oxygen can ever get free to unite with any other iron. So I think that the animal oil was the active agent in intensifying the corrosion, but it must have gotten oxygen from somewhere to unite with, in order to form the iron rust.

THE PRESIDENT. I am going to ask Mr. Schuhmann and Mr. Speller to answer with regard to the various points which have been made, as far as they can, and I also want them to give us their point of view on this question of marking their pipe, so we can know what pipe we are using. I am also going to ask them if they will not tell us something more about galvanizing and the methods of galvanizing which are used. Dr. Walker has emphasized the importance of having an absolutely uninterrupted coating of zinc, — I don't remember that he mentioned the thickness of it, — but there is a prevalent impression that galvanizing has been done in the last few years in a very economical manner. I think the members of the Association would like to learn what they can about that.

Mr. Schuhmann. In regard to galvanizing, it is the same thing as with the manufacture of wrought iron, that is, the old way is the best. We have been approached by different inventors who would claim that they could save us anywhere from $3.00 to $5.00 per ton by using their processes, but since the cost of labor is less than 10 per cent. of the cost of galvanizing, while the cost of zinc (spelter) is over 80 per cent., then such a great saving could only be effected by reducing the amount of zinc used, which means a reduction in the thickness of the coating, and for that reason we have declined all such offers, as we do not want to cheapen the goods at the expense of quality. We told these gentlemen that if they could bring us something that would make galvanizing better, we would consider it.

We are using the old process known as the " hot-metal process." The pipes are first pickled in a bath of dilute sulphuric acid, which removes grease, scale, etc. Then they are put in a tank of water to wash off the acid, and after that, put into another tank of dilute muriatic acid. After removal from this tank, the muriatic acid is allowed to dry on the pipes. They are then laid on top of the galvanizing kettle for a short period, to pre-heat them, and are then immersed in the molten zinc in a kettle containing about 60 000 lb. of this metal. They are allowed to remain in there long enough to get the same temperature as the molten zinc, and are then pulled out and held in an inclined position to allow the molten zinc to run out of the inside. Owing to the fact that wrought iron has a rougher surface than steel, the zinc coating will stick to it better and in thicker layers, so that you have not only a better metal as a base, but a heavier coating in addition.

I want to make a few remarks about the statements made by some of the gentlemen in reference to variation in the hardness of steel pipe, and in order to explain that I will have to give a little description of the manufacture of steel. Steel is generally manufactured in large quantities. They make about 15 tons at a blow of a Bessemer converter and anywhere from 25 to 50 tons at one heat of an open-hearth furnace. After the purification is completed, the steel is poured into large ladles and from them into large ingot molds, forming the so-called "ingots." After it is poured into ingots, the steel melter has finished his work. He cannot do any more to it. But the metal is too hot yet to permit rolling out. It must be allowed to cool first, and during this process of cooling some of the impurities still left in the steel will flock together in the liquid mass, which is technically known as "segregation." This has been fully discussed in some papers before the American Society for Testing Materials, and tests made with large steel boiler plates, by marking them off in squares like a large chess board and taking samples of the different squares, show large variations in the chemical composition as well as physical qualities. So, while it is possible to have hard and soft steel pipe made out of the same ingot, it is also possible that one end of a pipe may be soft, while the other end of the same pipe may be much harder.

Wrought iron is made in small quantities, about half a ton at a time, four men working alternately for about an hour and a half stirring it up so as to thoroughly purify the metal, and in that way the pure iron and the cinder become thoroughly mixed. After the puddle bars have been rolled out, they are cut up into shorter pieces and piled on top of each other, like bricks in a wall. This mixes the iron up similar to the way they mix salt-water taffy with the mixing machines, and the resulting product is of much more uniform quality, just as practical experience has demonstrated. We have not learned of anything yet by which the segregation of steel during the process of cooling can be prevented. Professor Stoughton states that segregated steel will corrode much faster than the same metal in which the impurities are evenly distributed, and he further qualifies the statement by saying that this segregation is always present to some extent in Bessemer and open-hearth steel, and that it is practically unknown in wrought iron.

In regard to the question asked by the President about marking the pipe, would say that we are making experiments with that now, but find it is not as easy as rolling the name in steel rails, for instance. We have tried one way by setting steel dies into the rolls, projecting slightly, so as to roll the name into the pipe. This makes a fairly good mark in black pipe, but after being galvanized it nearly all disappears again. If the impression is made too deep, then by cutting the pipe right where the name is, it may cause defective threads and consequently a leak. On the other hand, making the impression in the rolls so that the name will project outside the pipe, the planishing rolls will deface it again, or, if left too high, it may require filing off to cut threads. As stated above, we are still experimenting, and hope that before long we will be able to mark our pipe distinctly, because we are not ashamed to put our name on it.

If I understand Professor Walker's statement correctly, he bases his conclusion that there is no material difference between the corrosion of wrought-iron pipe and steel pipe on calculations made by measuring the depth of corrosion on partly corroded pipes under observation for a given time, and also on his erroneous assumption that the corrosion of both metals would have continued at the same ratio at which it started. A large number of tests made by other experimenters have proved that the corrosion of iron and steel is very irregular and erratic. Professor Stoughton, in his article on this subject in the *Engineering Magazine* of July, 1911, states that the rusting of some parts of a piece of steel will be more rapid than of other parts at first, and then conditions may change and the reverse will be the case. Moreover, some specimens will rust more rapidly than others at first and then more slowly. Professor Howe, in a similar paper read before the American Society for Testing Materials (Vol. 6, page 150), gives some very plausible theories as to why corrosion is not uniformly progressive. Such being the case, we feel that conclusions based on calculations of the supposed life of the pipes, by making micrometer measurements of the depth of partial corrosions, are as unreliable as accelerated corrosion tests, which, as we know, are entirely misleading. Fortunately, we have other tests, based on many years of actual experience under ordinary service conditions with wrought iron and steel pipe miles in length, weighing thousands of tons, and where corrosion continued until the holes penetrated the metal, and in all such cases of which a record has been kept the wrought iron was so far superior that it did not require calculations based on measurements to prove the greater durability of wrought iron under average service conditions.

In reference to the remarks made by the gentleman from Springfield, that no matter whether they used wrought-iron or steel pipe for service pipes, the water still retained its red discoloration, and assuming Professor Walker's explanation as correct, that the trouble was in the main, then it is but natural that the material out of which the service pipes were made had no influence on same, for if they had been made of glass it would not have changed the color of the water supplied by the mains.

MR. SPELLER. It is hardly necessary to say anything more about galvanizing, as Mr. Schuhmann clearly described the method we are using, that is, the old process of hot galvanizing. Many improvements have been suggested, but any process which promises a reduction in the amount of zinc applied to the surface must be considered with suspicion. No wiping operation should be permitted on galvanized pipe, as it is of the first importance to retain on the surface as much zinc as possible.

Most of the criticisms on steel pipe this afternoon have been on the matter of threading. This has been a surprise to me, as we have not heard much about this trouble of late years. Steel pipe as made direct from the ingot is softer, but at the same time tougher than wrought iron, and, therefore, slightly harder to thread, unless the dies are made with somewhat more rake and clearance than was the case when nothing but wrought-iron pipe was used. Most of the good dies on the market are now properly shaped, and will thread either iron or steel pipe without trouble. We have made a good deal of iron pipe in our time, and now that we are making nothing but soft steel pipe our threading practice is very much better. Fewer bad threads occur, and the speed of cutting has been increased, with a proportional economy in practice. You will find a properly cut thread on steel pipe is stronger and cleaner than can be made on wrought-iron pipe on account of the more homogeneous character of the metal.

Regarding the reference to hard spots in pipe, it would not surprise any one familiar with pipe business if the instance of this referred to turned out on examination to be the kind of wrought-iron pipe our friend Mr. Schuhmann was describing as being made of miscellaneous steel scrap. When steel scrap is bought for the manufacture of wrought-iron pipe (so called) it is impossible to be sure of its character, and consequently an occasional hard piece is likely to be worked in with the pipe. When steel is made for the manufacture of pipe exclusively, and rolled direct from the ingot, this cannot happen, for if the metal was not uniform or hard in places it would not weld, and would be a loss to the manufacturer. Moreover, no carbon additions are made to steel manufactured for pipe. The iron is refined to the lowest point and is relatively so low in carbon that segregation, if it does occur, can do no harm. So the remedy against possible hard spots is to purchase from the concerns who have control of their raw materials, and who can give satisfactory assurance that sound and uniform metal is put into their product. One important advantage which the steel pipe manufacturer has, where he is making pipe steel exclusively, is, that the product of the steel works is in the hands of a crew of trained experts who can be held responsible for the entire output as to quality. In making puddled iron, on the other hand, with the responsibility divided among a large number of puddlers, the same control is not possible, each man being a law unto himself within rather broad limits. Furthermore, we can speak from our own experience that it is no easy matter to recruit the ranks of the old-time puddlers, as the younger men are inclined to choose a less strenuous job where their skill can be used to better personal advantage.

As to the question of weight and thickness, that is entirely in the hands of the consumer. Steel pipe is now used for such a variety of purposes that it has been found necessary to make more than one standard weight for the same size, and this is also true of wrought iron to a certain extent. By specifying the weight required, and allowing a reasonable margin above or below for variation in manufacture, there should be no trouble in this respect.

Regarding the question of marking pipe with the name of the manufacturer: we have been in the practice of rolling our name on all lap-weld pipe for some time. It is comparatively easy to do this on lap-welded pipe where there is a mandrel on the inside to support the metal. However, marking butt-welded pipe where no mandrel is used is quite another matter. Most users of pipe naturally object to a depression being stamped in the surface, and some also object to having the raised letters on the pipe. I am glad to say we now have a process for rolling letters in relief on butt-welded pipe which will soon be put into practice so that the consumer may know that he is getting genuine steel pipe, made under a process which insures a maximum of uniformity and durability. By this system of marking it will be impossible to confuse this pipe with that made from steel scrap — or wrought iron.

THE PRESIDENT. Professor Walker, the Association is much indebted to you for coming here this afternoon and for explaining the nature of corrosion so clearly. Mr. Speller is a member of the Association, and I believe the Association has a rule that its members are not to be thanked; but I am sure we have appreciated his being here and doing his duty. Mr. Schuhmann, I think I voice the sentiment of the Association when I thank you for coming here to-day and telling us so much about your pipe and the method of its manufacture, and answering the questions which have been asked concerning it.

MR. RAYMOND W. PARLIN * (*by letter*). Mr. Albert Heard, superintendent and manager of the Washington County Water Company, states that that company completed its water works in July, 1882, at which time it began using one and one-half inch cast-iron B. &. S. pipe for services.

In 1887, after having had considerable trouble with the lead joints in the said pipes, they changed to one-inch extra heavy galvanized genuine wrought-iron pipe and have used the same since with good results. The character of the soil is red clay and lime stone. Some of this style of services have been in since 1882 and are to-day apparently in good condition.

The only trouble they have had is in some cases where the gutter was put in with a base of coal ashes or cinders, in which case the dampness percolating through them causes the pipe to corrode and to eat through for a short distance directly under the cinders, while the pipe on each side of the place has the galvanizing on it intact.

From a superficial examination it would appear that the trouble is caused by the galvanic action set up between the iron and the zinc by contact with the dilute acid from the cinders.

There are about 3 200 services, of which at least 2 400 are of galvanized pipe, and replacements do not average six a year.

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* Resident Engineer, Washington County Water Company, Hagerstown, Md.

Mr. Speller (*by letter*). Mr. Schuhmann in referring to conclusions reached from the many comparisons of iron and steel cited has failed to note that the samples were taken from pipe showing all stages of corrosion. (See average depth of pitting, Table 1, page 17.) The experience showed that the same comparisons obtained whether the corrosion was comparatively light or otherwise. In some cases the samples were taken from pipe which had been pitted through.

The depth of the deepest pits were taken in order to have some basis of comparison. No calculations or assumptions were made, nor was there any necessity for such, as we are here dealing with simple facts from specific experiences.

It is only lately that such comparisons could be looked for, as steel pipe is a comparatively modern product, and whatever the merits of the wrought iron prior to the advent of steel pipe, it is surely of more concern to know how steel pipe stands up compared with wrought iron made in our time where both were put in service together, under conditions which have prevailed during the past ten or fifteen years.

Professor Walker (*by letter*). It is evident from what Mr. Schuhmann says (page 34) that he did not understand the nature of the investigation which was conducted or the basis of the conclusion arrived at. Mr. Schuhmann mentions " his [Walker's] erroneous assumption that the corrosion of both metals would have continued at the same ratio at which it started," and then discusses the test as though the samples of pipe had been submerged in water for a few weeks or months. He is right in stating that a short time exposure is an unreliable basis from which to draw a conclusion; but such was here not the case. The pipe examined had been in service from two to seventeen years and the condition after long service is what is reported on, not a short laboratory test such as Mr. Schuhmann cites. As an indication of the condition of the pipe, not as a " calculation," as Mr. Schuhmann assumes, I give the measurement of those samples of pipe which were rusted to practical destruction, that is, where either the iron or the steel showed pits over one tenth of an inch in depth.

TABLE 2.

Sample — Number.	Depth of Pitting.		
	Mean of Ten Deepest Pits.	Deepest Pit.	Least of Ten Deepest Pits.
	Inches.	Inches.	Inches.
W-10 — Iron	.102	.134	.085
W-11 — Steel	.075	.095	.067
W-22 — Iron	.114	.160	.068
W-23 — Steel	.075	.107	.042
W-24 — Iron	.139	.168	.109
W-25 — Steel	.140	.204	.076
X-15 — Iron	.077	.101	.069
X-16 — Steel	.040	.047	.034
X-29 — Iron	.042	.060	.030
X-30 — Steel	.066	.103	.042
X-49 — Iron	.077	.113	.049
X-50 — Steel	.071	.122	.040
X-57 — Iron	.038	.110	.012
X-58 — Steel	.026	.053	.012
X-69 — Iron	.113	.159	.032
X-70 — Steel	.119	.177	.095
X-71 — Iron	.115	.169	.063
X-72 — Steel	.075	.156	.045

SOME THINGS DOMESTIC METERS DO NOT ACCOMPLISH.

BY WILLIAM S. JOHNSON.

[*Read February 14, 1912.*]

Five years ago it was the writer's privilege to present to this Association some facts relating to the consumption of water and the use of meters,* the chief object of the paper being to emphasize the fact that the use of domestic meters does not necessarily mean a low rate of consumption and the lack of meters a high rate, but that there are other conditions which have in many cases a greater influence on the quantity of water used and wasted than the method of charging for it.

In connection with the paper, statistics were presented, including all of the records which could be obtained, some of which showed results quite different from those commonly quoted to show what meters will accomplish. The discussion which followed seemed to indicate that if the figures did not show low consumption with the use of meters, the figures must be wrong.

Since this paper was presented I have had occasion to analyze the consumption of water in several towns, and interesting facts from other places have come to my attention showing even more clearly than the results presented five years ago some of the things which domestic meters do not accomplish, and showing also that any intelligent discussion of the probable saving of water by the introduction of meters should be preceded by a study of the conditions in the town to be metered.

It is very common now to find in a town suffering from a shortage of water, a number of enthusiasts who earnestly believe that the only thing needful is to introduce meters and thus solve the problem of a future water supply by reducing the consumption. The cities of Brockton and Fall River, with a consumption of about 40 gal. per person per day, are invariably cited as examples of what can be done in any municipality by the introduction of meters.

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*Journal, N. E. W. W. A., Vol. 21, p. 109.

In many of these places a study of the conditions shows that any such reduction of the consumption is absolutely impossible. A good example of this is the case of a Massachusetts town where there are perhaps 20 or 25 meters in use, and where there has been a lively agitation for the introduction of meters to relieve the shortage of water. Ten of the consumers already metered use for manufacturing or mechanical purposes enough water to make the average daily consumption in the town 35 gal. per person. The placing of meters upon all of the other 800 or 1 000 service pipes would undoubtedly reduce the consumption of water to some extent, but this town could never be in a class with Brockton, with its consumption of less than 40 gal. per person per day.

Other factors than the use of water for manufacturing purposes, some not so obvious, are almost universally overlooked. The stealing of water from fire-service supplies; leakage from mains and service pipes; and water used for flushing sewers, for drinking fountains, and other public purposes, are large items in the consumption of water, and the finding of one leak or of one case of stealing water may reduce the consumption more than the installation of hundreds of domestic meters.

As far as the saving of water is concerned, if I could not have both, I would choose every time to have some means of measuring the whole supply rather than to have every domestic service provided with a meter. The results accomplished at Holyoke, Southbridge, and other places when it was discovered by means of meters on the main pipes how much water was being used, show what can be accomplished by simply learning the necessity of doing something and having the encouragement of seeing the results of one's labors recorded on the meter chart.

Of course, in pumping systems this does not apply, for an idea can always be obtained — though sometimes a crude one — of the amount of water used by the counter on the pump.

I want to say that I believe most thoroughly in meters, and consider that the only proper way to sell water is by measure, and in calling attention to some of the things which meters do not accomplish I do it as an ardent " meter-man."

Meters do not prevent an increase in the quantity of water used for what may be termed legitimate purposes. This increase in the use of water, which has been referred to many times, is due chiefly to the increase in the number of plumbing fixtures, especially in the less expensive houses, and the increased quantity of water used in the modern fixtures. The rate of increase may be somewhat affected by the use of meters, but only to a slight extent, for householders are not likely to be deterred from the introduction of plumbing fixtures by the fact that the water is paid for by measure. In fact, the increased cost due to additional plumbing fixtures is generally less with meters than it is under fixtures rates.

This natural increase in use of water for domestic purposes is best shown in those places which have been thoroughly metered for many years and where there have been no great demands for water for manufacturing purposes. The increase in the per capita consumption at Brockton, which has been thoroughly metered for many years, was, between 1900 and 1910, 34 per cent. The increase in Fall River, another thoroughly metered city, during the same period, was 22 per cent. In North Attleboro, where all services are metered, the increase was 44 per cent. In Wellesley the increase in that time was 30 per cent., and in Worcester it was 7 per cent.

Comparing the increase in the ten-year period in these places thoroughly metered with places which have very few meters, it will be seen that, although the per capita consumption is generally larger, the percentage of increase is much the same. In Beverly, where only 4 per cent. of the services are metered, the increase was 26 per cent.; in Salem, 20 per cent.; in Danvers, 24 per cent., and in Newburyport, 63 per cent.

There are some unmetered towns in which the increase has been more rapid, such as Peabody, where the consumption increased 87 per cent., due largely to an increased use for manufacturing; but there are also unmetered towns where there has been a considerable decrease, such as Gardner, with a decrease of 34 per cent. in ten years, the reason for which will be given later.

To show the immediate effect of introducing meters the following table has been prepared in which the different cities and towns of Massachusetts, for which records of the consumption are available, have been grouped according to the increase in the percentage of services metered during the ten-year period from 1900 to 1910, and in the five-year period from 1905 to 1910, and the average increase in the consumption in each group has been obtained.

TABLE 1.

Increase in the Percentage of Services Metered.	From 1900 to 1910.		From 1905 to 1910.	
	Number of Places.	Increase in the Daily Consumption per Person (Gallons).	Number of Places.	Increase in the Daily Consumption per Person (Gallons).
Less than 10.......	24	15	44	6
From 10 to 25.....	14	11	16	1
More than 25......	15	8	18	—11

Meters will never make the consumption in two places the same if the character of the population in respect to their requirements for water are different. Manchester, with all services metered, uses 120 gal. per person per day; Dedham, 129 gal.; and Beverly, with 4 per cent. metered, uses 91 gal. per person per day. These places with large estates owned by wealthy men and with sprinklers in operation continuously during the summer on extensive lawns cannot be expected to have a consumption like that at Fall River, and yet in one of these places I have heard Fall River cited as an example of what might be accomplished there by the general introduction of meters.

In many places one of the reasons why domestic meters will not produce a low rate of consumption is that there is a large quantity of water used for manufacturing or mechanical purposes.

Table 2 gives statistics in regard to the consumption by large consumers in various places in Massachusetts.

Even in the so-called unmetered towns the water used for manufacturing purposes is generally metered and it is easy to determine this element in the consumption, which in many cases is an important one.

TABLE 2.

City or Town.	Population 1910.	Average Daily Consumption per Inhabitant.	Largest Single Consumer Uses:—		Ten Largest Consumers Use:—		Twenty Largest Consumers Use:—	
			Per Cent. of Total Consumption.	Gallons per Day per Inhabitant.	Per Cent. of Total Consumption.	Gallons per Day per Inhabitant.	Per Cent. of Total Consumption.	Gallons per Day per Inhabitant.
Amherst........	5 112	..	...	13.7	...	34.4	...	...
Attleboro.......	16 215	54	2.2	1.2	7.5	4.1	9.6	5.2
Billerica........	2 789	39	8.8	3.4	17.8	7.0	20.4	8.0
Brockton.......	56 878	39	2.0	0.8	8.2	3.2	10.9	4.3
Chelsea.........	32 452	87	...	...	...	...	21.1	18.4
Chicopee........	25 401	..	...	2.7	...	11.2	...	12.5
Clinton.........	13 075	45	7.3	3.3	22.4	10.2	26.0	11.8
Framingham....	12 948	48	11.3	5.5	23.8	11.5	27.2	13.2
Franklin........	5 641	61	8.8	5.3	23.4	14.2	26.0	15.8
Gardner........	14 699	44	2.4	1.1	10.9	4.8	13.2	5.8
Gloucester......	24 398	55	2.5	1.4	9.0	5.0	10.5	5.8
Greenfield.......	10 427	..	...	27.7	...	40.7	...	46.0
Haverhill.......	44 115	..	...	3.5	...	7.1	...	8.2
Holyoke........	57 730	103	1.1	1.2	7.8	8.1	12.0	12.4
Lawrence.......	85 892	45	5.6	2.5	14.7	6.6	16.8	7.6
Leominster......	17 580	..	...	10.7	...	34.4	...	42.3
Lowell..........	106 294	51	2.2	1.1	5.2	2.7	6.6	3.4
Lynn and Saugus	97 383	72	5.5	4.0	11.2	8.1	12.4	9.0
Malden.........	44 404	42	3.2	1.3	10.4	4.4	12.1	5.1

Marlboro.......	14 579	37	4.5	1.7	17.9	6.7	21.1	7.8
Middleboro.....	8 214	42	32.0	13.3	37.7	15.7	39.3	16.3
Milford.........	13 055	51	...	1.0	...	5.0	...	6.9
Milton.........	7 924	39	1.5	0.6	6.2	2.4	8.8	3.4
Monson........	4 758	..	...	1.5	...	...	...	3.3*
Natick.........	9 866	57	12.2	1.3	9.4	5.4	12.6	7.2
New Bedford....	96 652	81	2.5	2.1	15.4	12.5	24.0	19.5
Northampton....	19 431	..	...	6.7	...	21.9	...	24.7
Reading........	5 818	35	2.2	0.8	8.7	3.1	10.2	3.6
Springfield......	88 926	..	...	1.9	...	9.1	...	12.7
Taunton........	34 259	63	7.8	4.9	24.4	15.3	26.1	16.4
Weston.........	2 106	50	2.2	1.1	13.6	6.8	...	...
Winchendon.....	5 678	30	1.5	0.5	8.3	2.5	10.4	3.2
Worcester.......	145 986	74	...	...	...	...	19.3*	14.3*

* Total quantity used for manufacturing.

In the town of Peabody, for example, where only 7 per cent. of the services are metered, and the meters are placed only on the large consumers, the average daily consumption amounts to 152 gal. per person, and of this 64 per cent. is passed through the few meters. This amounts to 97 gal. per inhabitant per day.

In the town of Greenfield the quantity of water used by twenty of the large consumers amounts to 46 gal. per inhabitant per day. It would obviously be impossible to bring the per capita consumption to a very low figure in either of these towns by putting meters on all of the domestic services. In many places the rates charged large users of water are so low as to encourage the use by manufacturers of water from the public works rather than from private supplies, being in some cases less than the actual cost of supplying

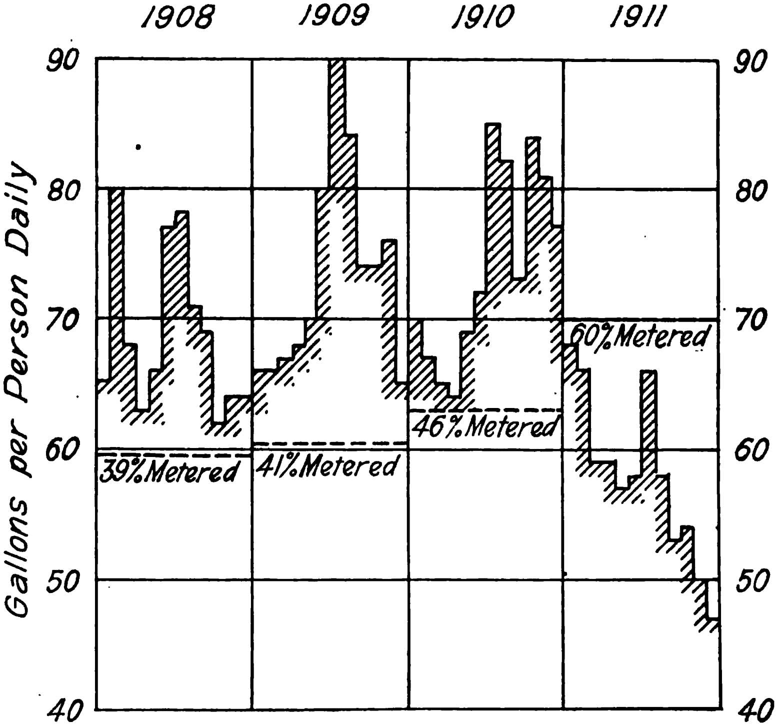

FIG. 1.
REDUCTION OF CONSUMPTION BY METERING A SINGLE SERVICE.

the water, and what is needed to reduce the consumption in such cases is not the introduction of domestic meters, but the introduction of more equitable water rates.

A better basis for comparing the domestic consumption would be to first deduct the quantity of water used for manufacturing and mechanical purposes. If this were done, it would be found that many of the great differences which appear in the per capita consumption would disappear. Thus, for example, if the consumption of water by the twenty largest consumers were deducted from the total consumption, it would leave in Brockton, where the reported consumption is 39 gal. per person per day, a domestic consumption of 35 gal. per person per day. In Taunton, where the reported consumption is 63 gal. per person per day, there would remain a domestic consumption of 47 gal. per person per day. The town of Peabody would have a domestic consumption of only 55 gal. per person per day instead of 152 gal. as reported. The domestic consumption, after deducting the manufacturing consumption, would be very much more nearly the same in the different places, and some of the places having low consumption, which now serve as examples of what meters will do, would change places with some of the other towns which report larger consumptions.

The quantity of water which is stolen from the pipes cannot be reduced by the introduction of domestic meters, and this item is of considerable importance, as I have had occasion to learn recently.

In a Massachusetts town having about one third of the services metered the consumption has been about 75 gal. per person per day for several years. (Fig. 1.) A little over a year ago the night consumption was so irregular that the engineer at the pumping station could detect it on his pressure gage indicating a heavy draft during certain hours. An investigation showed only one place where there could be any night draft sufficient to cause such irregularities and this was in a factory running all night and supplied with a large connection for fire protection. A meter was placed on this connection and the result was as shown on the diagram. The water had been stolen from the fire service at a rate of more than 200 000 gal. per day.

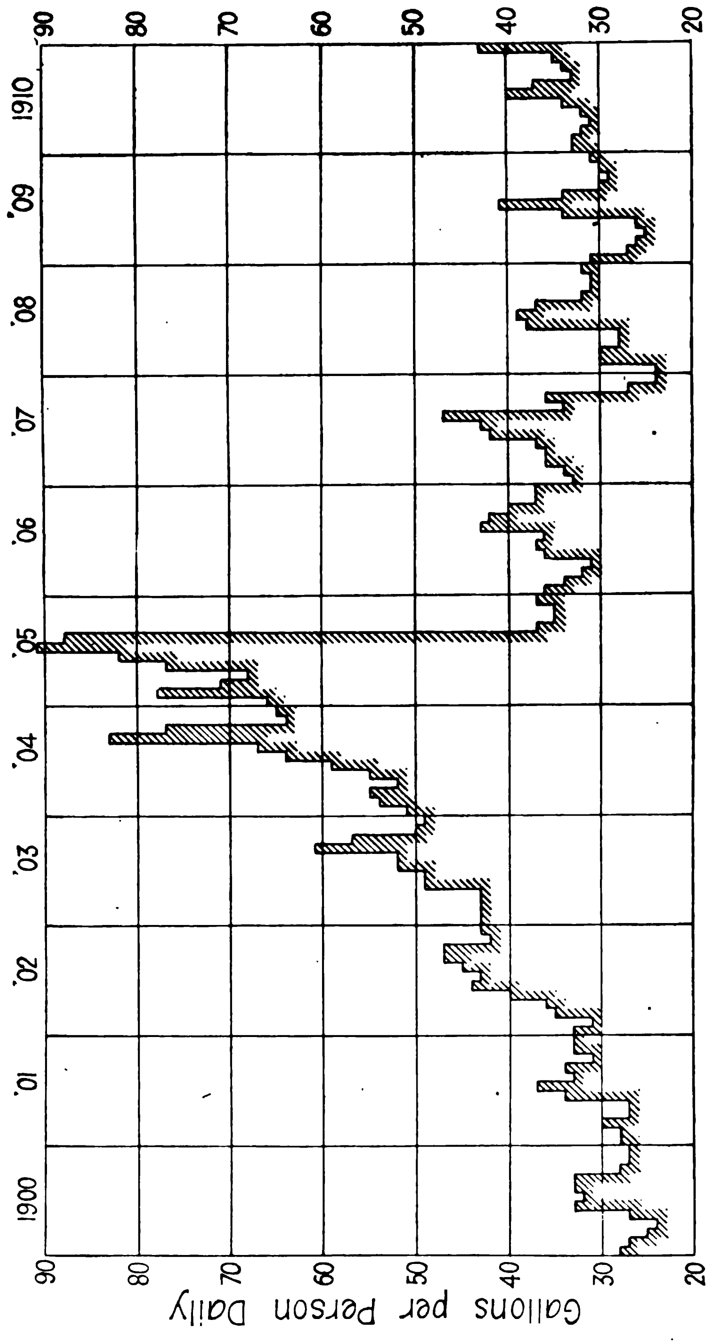

FIG. 2.
REDUCTION OF CONSUMPTION BY DISCOVERY OF A LEAK.

Not all of the gain shown on the diagram, however, can be attributed to this one cause. A considerable portion of the saving, especially during the latter part of the year, has been due to the placing of the new meters on services where it was expected they would do the most good instead of placing them only where requested by the consumer, as had been the custom previously. In most towns it is a fact that meters on a quarter of the services, if the services are intelligently selected, will accomplish three quarters of the saving of water which can be expected by metering every service.

Leakage from the mains and service pipes in the streets is another large source of loss of water which domestic meters do not affect. One of the best illustrations of this is shown in Fig. 2. In this town the consumption had been increasing at a rapid rate, and it seemed that an additional supply must be secured. In fact, investigations were already begun when some observant person noticed during the fall of 1905 that more water was coming out of one of the culverts than was entering at the other end, and it was discovered that there was a broken pipe which had been discharging into this culvert for an unknown period. In this town, undoubtedly, Fall River and Brockton were quoted, and it was maintained that the only proper solution of the water-supply problem was the introduction of meters, and yet by the discovery of a leak the consumption was reduced from 80 gal. to 35 gal. per person per day.

Another excellent illustration of what can be done without meters in reducing the consumption of water is found in Gardner, Mass. (Fig. 3.) The superintendent, Mr. Edwin L. Stone, a member of this Association, has given me permission to quote his statement as to the results accomplished.

"The superintendent having died in December, 1908, I was appointed superintendent by the Water Commissioners, March 1, 1909. As I was used to handling a plant which was 95 per cent. metered I naturally thought the consumption very large. It was the custom of the water department to make an inspection every two years and as this was the year for such an inspection a man was sent around to ascertain the number of fixtures and size of families and to find leaky fixtures. He was also armed with an aquaphone and instructed to listen for any unusual noise on the

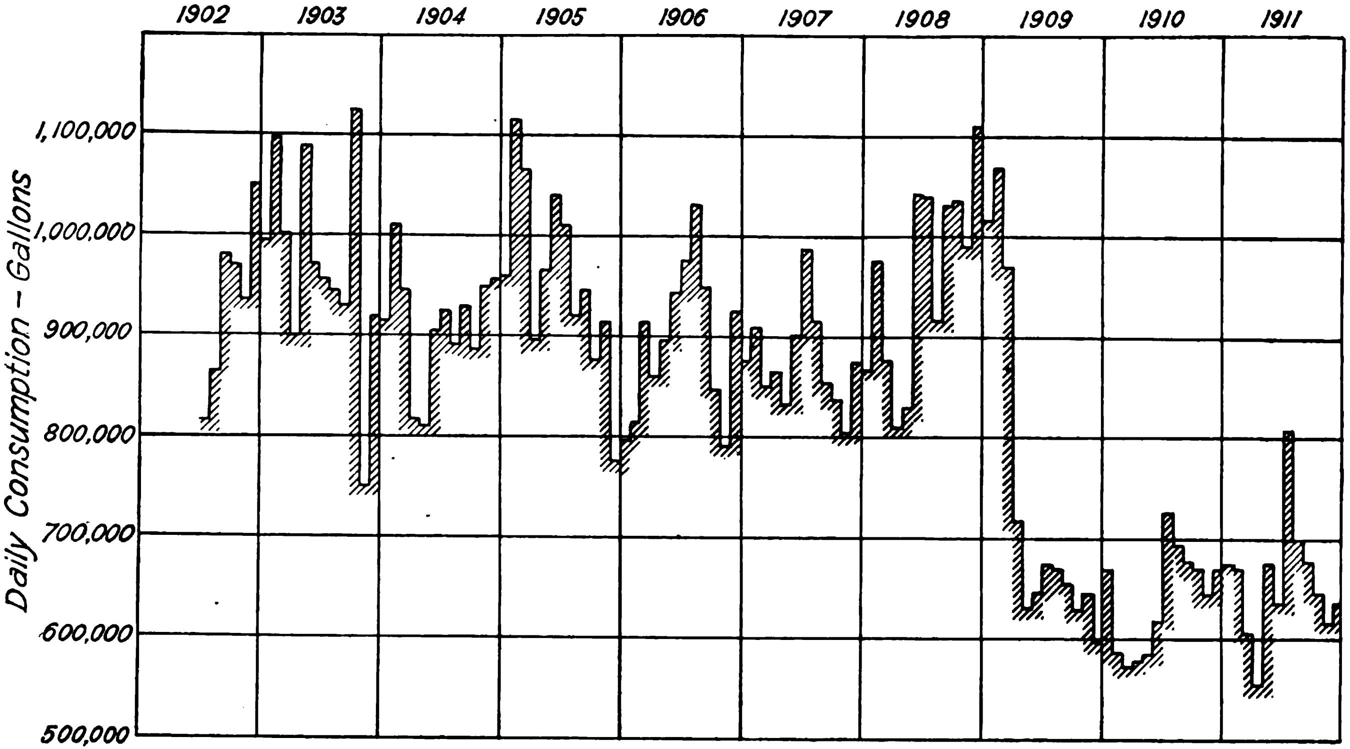

FIG. 3.

REDUCTION OF CONSUMPTION IN GARDNER, MASS., BY SYSTEM OF INSPECTION FOR LEAKS.

service pipes which might indicate leaks. Quite a few leaks were found in this way. Notice was at once sent from the office to have leaky fixtures repaired, and this was followed by another inspection of all leaky fixtures.

" As soon as the weather permitted I made a very careful inspection of all the hydrants and gates and in this way found many leaks in the main pipes and services, which, when fixed, made a big reduction in the water consumption. The result in the first year, nine months of which were under the new conditions, was a saving of 358 000 gal. per day, or a per capita consumption of about 54 gal. The result can be shown better by comparing the years 1908 and 1910, which gives a full year under the old conditions and a full year after the inspection was made

Daily consumption 1908, 1 100 745 gal. or 71 gal. per capita.
" " 1910, 640 602 " or 43 " " "

Saving, 460 143 gal. per day, or about 42 per cent.

" The leaks that were found and repaired were as follows:

100 to 150 leaky fixtures.
86 outside leaks.
43 joints.
8 pitted wrought-iron pipes.
3 gates.
2 breaks.
12 hydrants.
2 curb cocks.
8 lead connections.
1 ¾-in. pipe broken.
6 leaks were found on private fire services.

" I find it quite a problem after reducing the consumption to keep it within bounds. This I do by making a careful study of the consumption at all times, recording each day's consumption on a chart, noting the consumption particularly between 6 P.M. and 6 A.M. I will say, without the aquaphone and a Winslow recording instrument you are lacking the most valuable assistance. Too much value cannot be placed upon the aquaphone when in experienced hands.

" The water saving amounted to 168 000 000 gal. per year. There is no way of placing a value on this water, but taking the cost of our auxiliary pumping at Perley Brook, which is $24.42 per million, this made a saving to the town of about $4 100.

" There was a saving in the coal pile at the pumping station of 245 tons, which at $5.10 amounted to $1 250, or a total saving of $5 350 per year.

"Considering that we have only 6 per cent. of our services metered and have a per capita consumption of only 43.5 gal., or 366 gal. per tap, I feel well pleased, and find it a well-paying proposition to keep constantly after the leaks."

The quantity of water used for public purposes is frequently a large percentage of the total supply, and domestic meters do not remedy this. A drinking fountain will consume an enormous quantity of water unless properly regulated. Flush tanks on sewers, which fortunately are not common in this vicinity, use enormous quantities of water. In one city in another state, which is entirely metered, and where the quantity passed through meters was considerably less than half of the quantity pumped, it was found upon investigation that almost as much water was being used in the automatic flush tanks at the dead ends of sewers as was being passed through domestic meters.

A very unusual opportunity to study the effect of meters in a

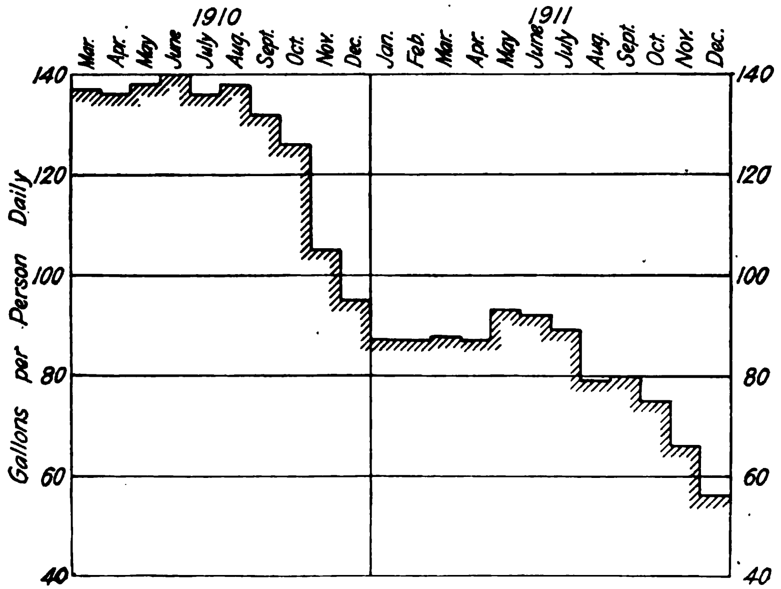

FIG. 4.

REDUCTION OF CONSUMPTION AT SOUTHBRIDGE WITH THE INSTALLATION OF A VENTURI METER.

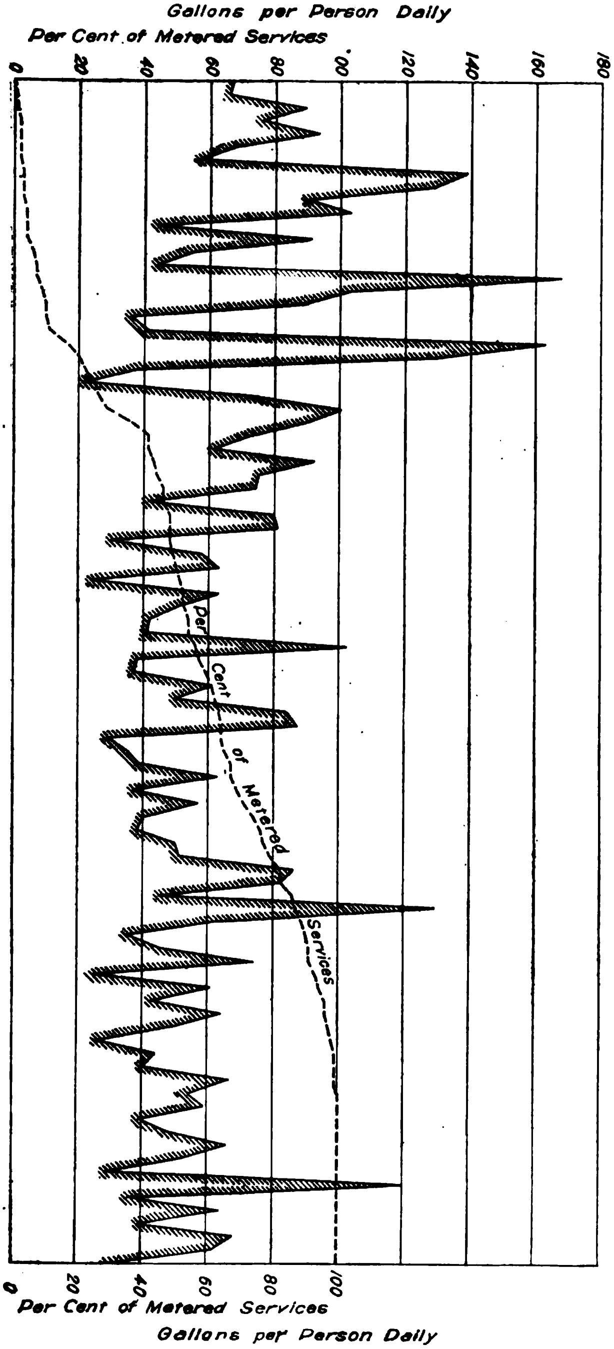
Gallons per Person Daily
Per Cent of Metered Services
0
20
40
60
80
100
120
140
160
180
Per Cent of Metered Services
0
20
40
60
80
100
Per Cent of Metered Services
Gallons per Person Daily

FIG. 5.

town previously entirely unmetered is found in Southbridge. (Fig. 4.) This town is supplied by gravity, and until early in 1910 there were practically no meters in operation and there was no means of measuring the total quantity used by the town. In May, 1910, a Venturi meter was put into operation, and it was found that the consumption was nearly 140 gal. per person per day. This led to an inspection, which revealed several large leaks, the most of which were in factory yards. As a result of the inspection alone, the consumption was reduced from 140 gal. to 90 gal. per person per day.

It was then decided to meter the services, and, as soon as the meters could be placed, every service in town was supplied with a meter. It is too early yet to ascertain the effect of this wholesale introduction of meters, but the consumption in December, 1911, was 56 gal. per person per day instead of 90 gal., which was the consumption after the inspection but before the introduction of meters.

The total reduction in consumption has amounted to more than 1 000 000 gal. per day, 60 per cent. of which was due to inspection stimulated by the introduction of a Venturi meter, and 40 per cent. was due to domestic meters.

For the purpose of showing in a general way the relation between the percentage of metered services and the per capita consumption I have plotted the consumption for 1910 in all Massachusetts cities and towns having consumption records, in order of the percentage of services metered. (Fig. 5.)

The places on the left of the diagram have very few meters, while those on the right are thoroughly metered. As would be expected, the high points occur generally among the places having few meters and those on the right among the metered towns can be accounted for. For example, the two highest points on the right of the diagram represent Manchester and Dedham, where a high consumption would be expected whether metered or unmetered.

Excluding the abnormal points the average consumption in the unmetered places is about 75 gal. per person per day, and in the metered cities and towns about 50 gal. It will be noticed that the reduction in consumption is much more rapid with the first 50 per cent. of services metered than with the last 50 per cent.

When we see side by side figures showing the total quantity of water used and the quantity passed through meters in those places where practically all of the services are metered, and find that generally only 60 per cent. and sometimes as little as 30 per cent. of the water is accounted for, it is plain that there is something yet to be done which the meters have not accomplished.

The slip of the pumps, and under-registration of meters, may account for some of the discrepancy, but when allowance is made for all of this, there still remains a large quantity of water which cannot be accounted for. This is where the efforts of the officials in those places which are already metered should be directed, and I have no doubt that as much can be accomplished in reducing the consumption in some of the towns which are already metered as in some of the places which are unmetered.

It seems to me that the only way by which we can avoid deceiving ourselves and others in regard to what meters are accomplishing is to separate the consumption of water into different classes, as was urged by Mr. Cole in a paper presented to the Association in 1910,* determining the quantity used for manufacturing, mechanical, and other purposes, and the quantity used for strictly domestic purposes. Then, instead of feeling that we have done our whole duty by putting meters on all services, let us reduce the "per centage unaccounted for" as has been done in some of the cases cited.

DISCUSSION.

MR. DEXTER BRACKETT.† This is a subject with which I have dealt for many years, and in which I have taken great interest. I agree with the speaker that the use of water meters will not prevent entirely the waste of water, or even as much as has been in many cases claimed by the advocates of water meters. I do, however, thoroughly believe that water meters should be used in connection with all water supplies, and they should be installed with the construction of the works. And, further, it is very desirable in works of any considerable size that the whole district may be divided into sections, so as to conveniently measure the quantity of water used on different portions of the works. In this way the quantities which are used and wasted, both by the individual takers and from street mains, can be determined.

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* JOURNAL N. E. W. W. A., Vol. 24, p. 636 (appointment of committee), and Vol. 25, p. 66 (Mr. Cole's paper).

† Chief Engineer, Metropolitan Water Works, Mass.

The conditions in different places are, as the speaker has stated, often very different. The city of Melrose may be considered as affording a fairly good example of the results which may be accomplished by the use of meters. In that city the per capita consumption in 1907 was 118 gal., and by the introduction of meters, and without any special effort to find leaks in the street mains, the consumption was reduced to 64 gal. in 1910, a saving of 54 gal. per capita. There is still opportunity for a considerable saving from leaks from the mains.

The adjoining town of Stoneham has several times largely reduced its consumption by finding leaks in the street mains, and at one time made a saving of about 300 000 gal. I say at one time, because subsequently the leakage from the street mains has increased, and has again been reduced in the same way, showing that there is need of constant vigilance.

Regarding the use of Venturi meters, I believe them to be very efficient instruments for the measurement of water, and very useful in connection with the detection of leaks, as by their use it is very easy to judge as to whether more water is being used during the night than is due to the proper consumption.

We have never made any careful scientific tests to determine the accuracy of the Venturi meters. There are sixty or more in constant use, measuring all the water that is used by the several cities and towns in the Metropolitan District. The water which is drawn from the reservoirs through the aqueducts is measured by means of current meters. A second measurement is made of the water by the displacement of the pumps at the pumping stations, and a third measurement is made by the several Venturi meters through which the several cities and towns are supplied. There are differences, due to leaks from some portions of our supply mains, which are not metered, but the three measurements from month to month agree within two per cent. I do not think there has been any month when it has been more than that, although possibly it may have been up as high as three per cent. This is not a strictly scientific method of testing the meters, but at the same time it is a practical test, and it shows that the meters are not far from correct, or, at any rate, if they are not correct, all the other measurements agree with them.

Mr. Allen W. Cuddeback.[*] It seems to me the primary object of domestic meters, and of all meters, is not necessarily to reduce the consumption of water, but rather to properly distribute the cost of water where it belongs. If the consumption is large and the domestic meters do not account for their proper proportion of the water, it puts the operating department on guard, and starts search for waste. Another important point, which has been brought to my attention during the recent cold spell, is this: We supply three towns. Two of them are 50 per cent. metered and the other is 100 per cent. metered. The consumption in the towns 50 per cent. metered has increased 50 per cent. in the recent cold spell, while the consumption in the town 100 per cent. metered has not increased at all. In this climate this is an important consideration, for often in periods like this the capacity of any plant may be overtaxed, where meters are not installed.

Mr. Brackett. I would like to ask the last speaker whether in the town where there was no increase in consumption the works had not been recently installed, that is, within the last ten years, or if the meters were not installed at the construction of the works.

Mr. Cuddeback. The meters were not installed at the construction of the works, but were installed only a few years afterwards; and the plumbing in the towns only 50 per cent. metered is somewhat older than in the town 100 per cent. metered. That is, the town 100 per cent. metered is a newer town.

Mr. Brackett. The results in the different cities and towns where we have made observations show that where meters have been applied to old plumbing, in Boston, for example, the householder will let the water run if the plumbing is liable to freeze, because it is cheaper to pay for the water than it is to pay for removing the plumbing. As an illustration of the effect of cold weather, the use of water in the Metropolitan District increased from 103 083 400 gal. in December, which was comparatively warm, to 136 631 000 in January, which was a cold month, an increase of 33 500 000 gal. per day.

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[*] Engineer and Superintendent, Passaic Water Company, Paterson, N. J.

Mr. Cuddeback. What percentage is that?

Mr. Brackett. Approximately 33 per cent.

Mr. Frank L. Fuller. Was that all due, Mr. Brackett, to allowing the water to run to prevent freezing?

Mr. Brackett. I know of no reason why the consumption should have been any larger in January than in December other than the effect of cold weather.

Mr. Fuller. Mr. President, during the last cold days I have allowed the water in my house to run a little at night. I have taken a reading in the morning and compared it with a reading during twenty-four hours when there was no water running to waste, and found a very slight increase. That may be due to the water not being registered, but whether it is or not it shows me that it is unnecessary to let a great deal of water run to prevent pipes freezing.

In regard to a simple method of finding leaks in the street mains, especially when works are new, I would like to say that after the pipes have been filled and the pressure put on to the system, a gage may be connected with a hydrant and then the section in which the hydrant is located shut off. When the last gate is shut, see whether the pressure is maintained, or whether it gradually falls off. If there is a leak of much consequence the pressure will reduce very quickly; if it is small, not so fast; if there is no leak at all it will be some time before there will be much decrease in the pressure. I suppose after the water has been let on to the houses, by keeping the faucets closed, the result would be the same. Certainly a leak of large or even of moderate size could be quickly detected. In a large city it would be a slow process, but in the ordinary town it would take only a short time to do it.

Mr. George A. Carpenter.* Mr. President, I have been impressed on several occasions with the effect of the different methods used in computing per capita consumption. I assume that the usual way is to take either the plunger displacement, which many of us have oftentimes found to be greatly in error, or the meter measurements from a large Venturi meter, and to divide these figures by the total population, thereby arriving at the per capita consumption.

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* City Engineer, Pawtucket, R. I.

Ten years ago, when investigating this subject, I was rather surprised to find how low were the figures of actual per capita consumption when arrived at by a different process. For example, studying a city in 1900, taking the census enumerators' returns by districts, the actual metered consumption of the several houses in these districts, and dividing this metered consumption by the actual population, I found a domestic consumption of 16.3 gal. per capita, leaving out the manufacturing consumption. Taking the manufacturing consumption into account, the per capita consumption became 41.8 gal. per day. Based on plunger displacement and the total population, the consumption figured 90 gal. per capita per day.

Ten years later, or in 1910, when making a second study of this same city, and following the same methods as before, the actual domestic consumption was found to be 19 gal. per capita per day, and including the water used for manufacturing purposes it became 58 gal. per capita per day. At the same time the total water consumption for the city, as measured by a Venturi meter and dividing by the population served, was 80 gal. per capita per day.

The above figures show how large a proportion of the figures reported as per capita consumption applies to that portion of the water which passes through drinking fountains, flush tanks, leakage from mains and services, or escapes in ways of which we have, at present, very little definite information.

PROCEEDINGS.

DECEMBER MEETING.

HOTEL BRUNSWICK,
BOSTON, December 13, 1911.

The President, Mr. Allen Hazen, in the chair.
The following members and guests were present:

HONORARY.

Mr. F. P. Stearns. —1.

MEMBERS.

S. A. Agnew, C. H. Baldwin, A. F. Ballou, L. M. Bancroft, T. H. Barnes, F. D. Berry, F. E. Bisbee, A. E. Blackmer, J. W. Blackmer, C. A. Bogardus, Dexter Brackett, E. C. Brooks, James Burnie, J. C. Chase, G. E. Crowell, A. W. Cuddeback, E. D. Eldredge, G. F. Evans, G. H. Finneran, F. F. Forbes, A. N. French, F. J. Gifford, A. S. Glover, Clarence Goldsmith, J. N. Goodell, F. W. Gow, F. H. Gunther, R. A. Hale, R. K. Hale, F. E. Hall, Allen Hazen, W. S. Johnson, E. W. Kent, Willard Kent, F. C. Kimball, G. A. King, Morris Knowles, N. A. McMillen, H. V. Macksey, A. E. Martin, F. E. Merrill, William Naylor, G. A. Nelson, F. L. Northrop, T. A. Peirce, H. E. Perry, J. L. Rice, L. C. Robinson, P. R. Sanders, H. W. Sanderson, A. L. Sawyer, C. W. Sherman, G. H. Snell, F. N. Speller, G. A. Stacy, T. V. Sullivan, H. A. Symonds, C. N. Taylor, L. A. Taylor, H. L. Thomas, R. J. Thomas, E. J. Titcomb, D. N. Tower, C. H. Tuttle, W. H. Vaughn, G. E. Winslow. — 66.

ASSOCIATES.

Ashton Valve Company, by C. W. Houghton and H. W. Ashton; Builders Iron Foundry Company, by F. N. Connet and A. B. Coulters; Darling Pump and Manufacturing Company, Ltd., by H. H. Davis; George E. Gilchrist Company, by G. E. Gilchrist; Goulds Manufacturing Company, by R. E. Hall; *Engineering Record*, by I. S. Holbrook; Hersey Manufacturing Company, by A. S. Glover, H. D. Winton, and W. A. Hersey; Fred A. Houdlette & Son, Inc., by M. S. Kahurl; Lead Lined Iron Pipe Company, by T. E. Dwyer; Ludlow Valve Manufacturing Company, by H. F. Gould; Charles Millar & Son Co., by C. F. Glavin; Mueller Manufacturing Company, by G. A. Caldwell; National Meter Company, by C. H. Baldwin, J. G. Lufkin, and H. L. Weston; Neptune Meter Company, by R. D. Wertz; Pittsburg Meter Company, by R. A. Lester; Platt Iron Works Company, by F. H. Hayes; Rensselaer Valve Company, by F. S. Bates and C. L. Brown; A. P. Smith Manufacturing Company, by F. L. Northrop; Thomson Meter Company, by E. W. Shedd; Walworth Manufacturing Company, by E. H. Rice; R. D. Wood & Co., by E. J. Lame; Henry E. Worthington, by Samuel Harrison. — 30.

GUESTS.

J. G. Hill and R. W. Van Tassell, water commissioners, Lowell, Mass.; George Smith and John G. Howland, Springfield, Mass.; S. W. Hildreth, water commissioner, and J. L. Hyde, town engineer, Westfield, Mass.; F. M. Griswold, National Fire Prevention Association, New York City; B. E. Warren, Nashua, N. H.; Harry Barker, *Engineering News*, New York City; E. J. Mishler and George Schuhmann, Reading, Pa.; George H. Perry, E. F. Hughes, and Prof. W. H. Walker, Boston, Mass.; A. W. Powers, Cohoes, N. Y. — 15.

The Secretary read applications for membership, duly approved, from:

Active: Charles H. Ross, superintendent Waterloo Water Company, Waterloo, N. Y.; Alfred H. Young, superintendent Jewett City Water Company, Jewett City, Conn.; W. E. Miller, C. E., Madison, Wis., engaged in railway, gas, and water engineering; John L. Hyde, Westfield, Mass., engaged in municipal engineering.

Associate: Eddy Valve Company, Waterford, N. Y., manufacturers of valves, hydrants, etc.

On motion of Mr. Sherman, the Secretary was directed to cast one ballot in favor of the applicants, and he having done so they were declared duly elected members of the Association.

Mr. William H. Walker, professor of chemical engineering, Massachusetts Institute of Technology, presented a paper entitled, "An Investigation of the Relative Life of Iron and Steel Pipe as Found in Actual Service." The discussion was opened by Mr. F. N. Speller, metallurgical engineer, Pittsburg, Pa., representing steel-pipe manufacturers, and he was followed by Mr. George Schuhmann, vice-president and general manager of the Reading Iron Company, representing the manufacturers of wrought-iron pipe, and by Mr. Kahurl, representing the new product manufactured by the American Rolling Mills Company. The discussion was also participated in by Mr. Smith of Springfield, Mr. Dexter Brackett, Mr. Robert J. Thomas, Mr. Edwin C. Brooks, Mr. Richard A. Hale, Mr. William F. Sullivan, Mr. George A. Stacy, Mr. F. N. Connet, and Professor Walker; and Mr. Schuhmann and Mr. Speller closed the discussion.

Adjourned.

ANNUAL MEETING.

HOTEL BRUNSWICK,
BOSTON, MASS., January 10, 1912.

The President, Mr. Allen Hazen, in the chair.

The following members and guests were present:

MEMBERS.

S. A. Agnew, M. N. Baker, C. H. Baldwin, L. M. Bancroft, Randolph Bainbridge, F. A. Barbour, H. K. Barrows, C. W. Batchelder, A. E. Blackmer, J. W. Blackmer, C. A. Bogardus, George Bowers, Dexter Brackett, James Burnie, G. A. Carpenter, C. E. Chandler, H. H. Chase, P. M. Churchill, R. C. P. Coggeshall, M. F. Collins, J. H. Cook, John Doyle, E. R. Dyer, J. L. Dower, E. D. Eldridge, B. R. Felton, G. H. Finneran, J. H. Flynn, F. L. Fuller, Clarence Goldsmith, F. J. Gifford, A. S. Glover, J. M. Goodell, F. H. Gunther, R. K. Hale, E. A. W. Hammatt, W. E. Hannan, A. R. Hathaway, T. G. Hazard, Jr., Allen Hazen, D. A. Heffernan, M. F. Hicks, H. K. Higgins, C. L. Howes, W. S. Johnson, A. W. Jepson, E. W. Kent, Willard Kent, F. C. Kimball, G. A. King, Morris Knowles, E. E. Lochridge, F. A. McInnes, S. H. McKenzie, W. A. McKenzie, N. A. McMillen, A. E. Martin, John Mayo, F. E. Merrill, Leonard Metcalf, H. A. Miller, E. L. Northrop, T. A. Peirce, W. J. Sando, C. M. Saville, J. Waldo Smith, Sidney Smith, G. H. Snell, G. A. Stacy, C. T. Treadway, W. F. Sullivan, J. A. Tilden, C. H. Tuttle, W. H. Vaughn, J. H. Walsh, L. R. Washburn, R. S. Weston. — 77.

ASSOCIATES.

Anderson Coupling Company, by C. E. Pratt; Builders Iron Foundry, by F. N. Connet and A. B. Coulters; Chapman Valve Manufacturing Company, by Robert Shirley and H. L. DeWolfe; Goulds Manufacturing Company, by R. E. Hall; *Engineering Record*, by I. S. Holbrook; Darling Pump and Manufacturing Company (Ltd.), by J. L. Hough and H. H. Davis; F. H. Hayes Machinery Company, by F. H. Hayes; Hersey Manufacturing Company, by

Albert S. Glover, J. A. Tilden, and W. A. Hersey; Kennedy Valve Company, by F. C. Flinn; Lead Lined Iron Pipe Company, by T. E. Dwyer; Ludlow Valve Manufacturing Company, by H. F. Gould; Charles Millar & Son Company, by C. F. Glavin; H. Mueller Manufacturing Company, by G. A. Caldwell; National Meter Company, by C. H. Baldwin and J. G. Lufkin; Norwood Engineering Company, by H. M. Hosford and C. E. Childs; Rensselaer Manufacturing Company, by C. L. Brown and F. S. Bates; A. P. Smith Manufacturing Company, by F. L. Northrop; Union Water Meter Company, by Edwin P. King and E. K. Otis; United States Cast Iron Pipe and Foundry Company, by D. B. Stokes; Waldo Bros., by H. E. Browne; Water Works Equipment Company, by W. H. Van Winkle; R. D. Wood & Co., by C. R. Wood and W. M. Simmons. — 32.

GUESTS.

S. Pitcher, Worcester, Mass.; W. G. Newhall, Portland, Me.; I. W. Flower, Roe Stephens Manufacturing Company, Detroit, Mich.; H. M. Lofton, general manager Columbian Iron Works, Chattanooga, Tenn.; George E. Felber, Pittsburg Valve Company, Pittsburg, Pa.; W. L. Sharpe, chairman, and Albert S. Benson, chemist, East Greenwich, R. I.; Prof. Kendnon and A. J. Loepsinger, Providence, R. I.; Thomas T. O'Connell, water commissioner, Wakefield, Mass.; George W. Bowers, Lowell, Mass.; A. C. Dickerman, Edward C. Sherman, Frederick A. Cole, and Edward F. Hughes, Boston, Mass. — 15.

The President then introduced Mr. David I. Walsh who made a brief address to the Association.

The Secretary presented applications for active membership, properly endorsed and represented by the Executive Committee, from the following:

Lewis L. Wadsworth, Winchester, Mass., engaged in construction of fortifications, power houses, water and sewer works, for the Federal Government, and in building concrete bridges and in general work; Paul Hansen, University of Illinois, Urbana, Ill., engineering assistant, Massachusetts State Board of Health, chief engineer Ohio State Board of Health, state sanitary engineer of Kentucky, and at present engineer of the Illinois State Water Survey; Hervey A. Hanscom, West Medford, Mass., has been engaged in construction of Metropolitan Water Board's mains, Springfield steel main, Medway, Norton, and Barnstable complete water systems, and other New England plants; Herbert F. Salmonde, Westfield, Mass., has been engaged as chemist, Sanitary

District, Chicago, Ill., chemist Board of Health, Chicago, Ill., and at present chemist West Parish Filters (Springfield Water Works), Westfield, Mass.; Harington P. Stearns, Far Rockaway, N. Y., with the Queens County Water Company; Sam H. Pitcher, Worcester, Mass., assistant engineer city of Worcester.

On motion the Secretary was instructed to cast the ballot of the Association in favor of the applicants named, and he having done so they were declared duly elected members of the Association.

The Secretary read the following communication:

WATER DEPARTMENT,
BANGOR, ME., January 8, 1912.

MR. WILLARD KENT, *Secretary*
N. E. Water Works Association,
Tremont Temple, Boston, Mass.

Dear Sir, — I have been unable to secure any data from my own proceedings or from those of my father in regard to the effect of an alternating electric current on a pipe, from the standpoint of electrolysis. We have had the matter before us for some time, and have not come to any definite decision. Some state that they consider it as dangerous as the direct, and others claim it is harmless, and the greater number does not know.

Can you give me any information, or refer me to any one who can? Thanking you in advance for your kindness, I remain,

Yours very truly,
HAROLD H. SINCLAIR.

THE PRESIDENT. Is there any one who can inform Mr. Sinclair upon this important point? The alternating current is coming into fashion, and it is something we shall have to investigate.

The following reports of the officers of the Association were received:

REPORT OF THE SECRETARY.

Mr. President and Gentlemen of the New England Water Works Association, — Your Secretary submits the following report of the changes in the membership and general condition of the Association for the year ending December 31, 1911.

NEW ENGLAND WATER WORKS ASSOCIATION.

Year.	President.	Membership at End of Year.				Annual Convention.		Receipts.	Expenditures.	Cash Balance.
		Members.	Associate.	Honorary.	Total.	Place.	Date.			
1882	(Organized)	27	—	—	27	Boston, Mass.	June 21, '82			
1882–3	*James W. Lyon	37	6	—	43	Worcester, Mass.	June 21, '83	$245.00	$87.86	$157.14
1883–4	Frank E. Hall	48	9	—	57	Lowell, Mass.	June 19–20, '84	156.14	171.90	141.38
1884–5	*George A. Ellis	83	44	—	127	Springfield, Mass.	June 18–19, '85	651.84	511.44	281.78
1885–6	R. C. P. Coggeshall	106	47	—	153	New Bedford, Mass.	June 16–18, '86	1 658.50	1 643.42	296.86
1886–7	*Henry W. Rogers	137	52	2	191	Manchester, N. H.	June 15–17, '87	1 342.28	1 066.98	572.16
1887–8	*Edwin Darling	181	54	3	238	Providence, R. I.	June 13–15, '88	2 013.30	1 697.15	888.31
1888–9	*Hiram Nevons	209	64	4	277	Fall River, Mass.	June 12–14, '89	2 204.07	2 127.70	964.68
1889–90	Dexter Brackett	257	73	5	335	Portland, Me.	June 11–13, '90	2 511.27	2 346.65	1 129.30
1890–1	*Albert F. Noyes	281	74	5	360	Hartford, Conn.	June 10–12, '91	3 055.13	1 884.78	2 299.65
1891–2	Horace G. Holden	290	70	5	365	Holyoke, Mass.	June 8–10, '92	2 887.17	3 278.54	1 908.28
1892–3	*George F. Chace	338	69	5	412	Worcester, Mass.	June 14–16, '93	3 422.61	3 317.22	2 013.67
1893–4	*Geo. E. Batchelder	365	73	5	443	Boston, Mass.	June 14–16, '94	3 208.85	3 259.07	1 963.45
1894–5	George A. Stacy	401	81	5	487	Burlington, Vt.	Sept. 11–13, '95	3 147.41	3 115.99	2 673.03
1895–6	Desmond FitzGerald	442	82	5	529	Lynn, Mass.	June 10–12, '96	3 179.91	3 148.49	2 704.45
1896–7	*John C. Haskell	464	80	5	549	Newport, R. I.	Sept. 8–10, '97	3 340.23	3 322.94	2 721.74
1897–8	Willard Kent	488	77	5	570	Portsmouth, N. H.	Sept. 14–16, '98	3 002.13	2 786.95	2 936.92
1898–9	Fayette F. Forbes	494	73	5	572	Syracuse, N. Y.	Sept. 13–15, '99	2 825.71	3 050.23	2 712.40
1899–1900	Byron I. Cook	519	70	5	594	Rutland, Vt.	Sept. 19–20, '00	4 920.49	5 524.65	2 108.24
1901	Frank H. Crandall	493	58	4	555	Portland, Me.	Sept. 18–20, '01	4 238.55	4 283.22	2 063.57
1902	Frank E. Merrill	522	60	5	587	Boston, Mass.	Sept. 10–12, '02	5 158.48	4 680.32	2 541.73
1903	Charles K. Walker	520	55	3	586	Montreal, Canada	Sept. 9–11, '03	5 032.40	4 505.08	3 069.05
1904	Edwin C. Brooks	538	58	8	604	Holyoke, Mass.	Sept. 14–16, '04	5 328.31	5 528.21	2 869.15
1905	George Bowers	584	53	8	645	New York, N. Y.	Sept. 13–16, '05	5 431.16	5 411.58	2 888.73
1906	Wm. T. Sedgwick	618	51	15	684	White Mts., N. H.	Sept. 12–14, '06	5 366.94	4 845.14	3 410.53
1907	John C. Whitney	636	51	15	692	Springfield, Mass.	Sept. 11–13, '07	5 291.83	†4 222.06	4 480.30
1908	Alfred E. Martin	633	49	14	696	Atlantic City, N. J.	Sept. 23–25, '08	5 706.36	7 475.56	‡2 711.10
1909	Robert J. Thomas	647	55	13	715	New York, N. Y.	Sept. 8–10, '09	5 305.31	†4 566.84	‡3 449.57
1910	George A. King	678	56	13	747	Rochester, N. Y.	Sept. 21–23, '10	6 507.08	†7 237.60	‡2 719.05
1911	Allen Hazen	680	58	12	750	Gloucester, Mass.	Sept. 13–15, '11	6 440.90	†6 279.72	‡2 880.23

* Deceased.

† Not including December JOURNAL and reprints.

‡ Does not include $1 815 invested in bonds.

MEMBERSHIP.

The present membership of the Association is 750; that of one year ago was 747, a gain of 3 during the year.

The detailed statement of the changes in membership during the past year in the several grades is as follows.

MEMBERS.

January 1, 1911.	Honorary members	13			
	Deceased	1			12
January 1, 1911.	Total members		678		
	Withdrawals:				
	Resigned	18			
	Dropped	27			
	Died	9	54		
				624	
	Initiations:				
	January	2			
	February	5			
	March	9			
	April	7			
	June	7			
	September	10			
	November	2			
	December	4	46		
	One member elected in 1910, but qualified in 1911		1	47	
	Reinstated:				
	Members dropped in 1911		9	9	
					680
January 1, 1911.	Total associates		56		
	Withdrawals:				
	Resigned		2	54	
	Reinstated:				
	Associate resigned in 1909		1	1	
	Initiations:				
	September	2			
	December	1		3	
					58
January 1, 1912.	Total membership				750

The Secretary has received $6 249.71, which has been paid to the Treasurer, and has certified for payment bills amounting to $3 349.86.

A statement of the receipts, expenditures, accounts receivable and bills payable will be found in detail in the report of the Treasurer.

Respectfully submitted,
WILLARD KENT, *Secretary.*

The Treasurer, Mr. Lewis M. Bancroft, submitted the following report.

CLASSIFICATION OF RECEIPTS AND EXPENDITURES.

Receipts.

Dividends and interest		$191.19
Initiation fees	$223.00	
Dues	2 871.00	
Total received from members		3 094.00
JOURNAL:		
Advertisements	$1 763.75	
Subscriptions	183.00	
Sale of JOURNALS	279.25	
Sale of Reprints	40.89	
Total received from JOURNAL		2 266.89
Miscellaneous receipts:		
Sale of " Pipe Specifications "	$61.80	
Dinners	821.00	
Sundries	6.02	
Total miscellaneous receipts		888.82
Total receipts		$6 440.90

Expenditures.

JOURNAL:	
Advertising agent, commission	$271.50
Plates	146.17
Printing	2 117.06
Editor's salary	300.00
Expense	52.19
Amount carried forward	$2 886.92

Amount brought forward		$2 886.92	
Reporting		58.25	
Reprints		222.25	
Envelopes		28.50	
Miscellaneous		13.00	
			$3 208.92
Office:			
Secretary, salary		$150.00	
Expense		46.27	
Assistant Secretary, salary		600.00	
Expense		139.26	
Rent		300.00	
Printing		12.50	
Membership list		186.25	
Stationery		84.86	
Envelopes and postage		134.60	
Library		6.25	
Miscellaneous		24.00	
			1 683.99
Meetings and Committees:			
Stereopticon		$68.66	
Dinners	$830.00		
Cigars	57.90		
Music	87.00		
		974.90	
Badges		55.50	
Circulars		153.50	
			1 252.56
Treasurer's salary and bond			67.50
" Pipe Specifications "			55.00
Miscellaneous expenses			11.75
Total expenses			$6 279.72

The Auditing Committee submitted the following report:

BOSTON, MASS., January 9, 1912.

We have examined the accounts of the Secretary and Treasurer of the New England Water Works Association, and find the books correctly kept and the various expenditures of the past year supported by duly approved vouchers.

Respectfully submitted,

GEORGE H. FINNERAN,
ALBERT L. SAWYER,
JOHN H. WALSH,
Auditing Committee.

REPORT OF TREASURER.

Lewis M. Bancroft, Treasurer,
In account with the New England Water Works Association.

	RECEIPTS.		EXPENDITURES.		
1911.					
Jan. 1.	Cash on hand	$2 719.05	Bills paid		$6 279.72
	Received of Willard Kent, Sec'y	6 249.71	BALANCE ON HAND.		
	Interest on bonds and deposits	191.19	People's Savings Bank	$1 874.56	
			Mechanics Savings Bank	936.36	
			First National Bank	66.30	
			Liberty Trust Co.	3.01	2 880.23
		$9 159.95			$9 159.95

ASSETS AND LIABILITIES.

ASSETS.			LIABILITIES.		
Cash, balance in banks		$2 880.23	Accounts payable:		
Bonds Nos. 2642 and 2644, Lake Shore & Mich. So. R. R., 4%, due May 1, 1931. Book value, $1 815. Market value		1 865.00	Secretary's salary and expenses	$55.00	
Accounts receivable:			Secretary's incidentals	21.44	
Advertising	$598.75		December Journal and reprints	305.26	
Sale of Journals	7.00		Editor's salary and expenses	82.00	
Reprints	14.00		Reporting	81.50	
Specifications	.60	620.35	Rent	100.00	$645.20
			Surplus		4 720.38
		$5 365.58			$5 365.58

Reading, Mass., January 9, 1912.

LEWIS M. BANCROFT, *Treasurer*.

The Editor, Mr. Richard K. Hale, submitted the following report:

REPORT OF THE EDITOR.

BOSTON, January 10, 1912.

To the New England Water Works Association, — I present the following report for the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION for the year 1911.

The accompanying tabulated statements show in detail the amount of material in the JOURNAL; the receipts and expenditures on account of the JOURNAL for the past year (including the cost of the December JOURNAL and reprints, bills for which were received too late to pay in 1911, and which are consequently not included in the Treasurer's statement); and a comparison with the conditions of preceding years.

Size of Volume. — The volume is somewhat smaller in total pages and pages of text than that of several preceding years.

Illustrations. — The total cost of illustrations for the year, including printing, has been $270.12, or 10.3 per cent. of the gross cost of the volume.

Reprints. — The usual fifty reprints of papers have been furnished to authors without charge, and additional reprints, when desired, at the cost of the paper and press work. The net cost to the Association for reprints has been $127.20. There have been no advance copies of papers prepared during the year.

Circulation. — The present circulation of the JOURNAL is:

Members, all grades	750
Subscribers	61
Exchanges	29
Total	840

an increase of 13 over the preceding year. JOURNALS have also been sent to 48 advertisers.

Advertisements. — There has been an average of 27 pages of paid advertising, with an income of $1 763.75, a slight increase over last year.

Pipe Specifications. — During the year the specifications for cast-iron pipe to the value of $61.80 have been sold. One thousand copies have been printed, at a cost of $55.00, representing a net gain of $6.80 for the year. The net gain up to a year ago had been $207.25, so that the total net gain from this source to date is $214.05. There are still about 582 copies of specifications on hand, or about $58.20 worth if sold at retail.

The Association has a credit of $4.61 at the Boston Post-Office, being the balance of the money deposited for payment of postage upon the JOURNAL at pound rates.

There are no outstanding bills, on account of the JOURNAL, which are not included in these tables.

Respectfully submitted,

RICHARD K. HALE, *Editor.*

TABLE No. 1.

STATEMENT OF MATERIAL IN VOLUME XXV, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1911.

Number.	Date.	PAGES OF									Total Cuts.
		Papers.	Proceedings.	Total Text.	Membership Changes.	Index.	Advertisements.	Cover and Contents.	Inset Plates.	Total.	
1	March	144	45	189	—	—	32	4	9	234	26
2	June	87	7	94	—	—	32	4	5	135	5
3	September . . .	107	15	122	2	—	32	4	8	168	22
4	December . . .	65	5	70	1	6	32	4	4	117	4
	Total . . .	403	72	475	3	6	128	16	26	654	57

TABLE No. 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XXV, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1911.

Receipts.		*Expenditures.*	
From advertisements . . .	$1 763.75	For printing JOURNAL . .	$1 440.31
From sale of JOURNAL . .	279.25	For printing illustrations .	97.75
From sale of reprints . . .	47.05	For preparing illustrations,	172.37
Subscriptions	183.00	For editor's salary	300.00
		For editor's incidentals . .	31.94
	$2 273.05	For advertising agent's commissions	269.50
Net cost of JOURNAL . . .	352.82	For reporting	139.75
		For reprints	174.25
	$2 625.87		$2 625.87

TABLE No. 3.

COMPARISON BETWEEN VOLUMES XVII TO XXV INCLUSIVE, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	VOL. XVII.	VOL. XVIII.	VOL. XIX.	VOL. XX.	VOL. XXI.	VOL. XXII.	VOL. XXIII.	VOL. XXIV.	VOL. XXV.
	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.
Average edition (copies printed)	1 200	900	900	900	1 085	1 000	1 000	1 150	1 000
Average membership	587	596	625	665	693	699	710	732	752
Circulation at end of year	656*	667	705	767	785	780	802	827	840
Pages of text	430	491	587	495	500	500	459	643	475
Pages of text per 1 000 members	733	824	939	745	722	715	646	880	632
Total pages, all kinds	619	794	784	662	669	681	627	808	654
Total pages per 1 000 members	1 051	1 332	1 254	995	964	976	884	1 090	870
GROSS COST:									
Total	$2 706.05	$2 928.77	$3 266.65	$2 573.61	$2 643.42	$2 733.61	$3 111.15	$3 490.81	$2 625.87
Per page	4.38	3.69	4.17	3.88	3.95	4.01	4.97	4.32	4.02
Per member	4.61	4.91	5.23	3.87	3.82	3.91	4.39	4.78	3.50
Per member per 1 000 pages	7.46	6.18	6.67	5.85	5.70	5.88	7.00	5.90	4.09
Per member per 1 000 pp. text	10.72	10.00	8.91	7.81	7.62	8.02	9.56	7.44	7.36
NET COST:									
Total	$770.62	$648.11	$1 072.95	$387.96	$483.15	$131.06	$789.98	$1 334.06	$352.82
Per page	1.25	.82	1.37	.58	.72	.19	1.26	1.65	.54
Per member	1.31	1.09	1.72	.58	.70	.19	1.11	1.82	.47
Per member per 1 000 pages	2.12	1.30	2.20	.88	1.04	.28	1.78	2.25	.55
Per member per 1 000 pp. text	3.05	2.22	2.93	1.18	1.39	.39	2.43	2.83	.98

* Exclusive of three hundred sample copies.

On motion of Mr. Coggeshall it was voted that the reports of the Secretary, Treasurer, Auditing Committee, and Editor be received and placed on file.

The President then called for the report of the Committee "to look after and keep track of legislation and other matters pertaining to the Conservation, Development, and Utilization of the Natural Resources of the Country," Mr. M. N. Baker, chairman.

REPORT OF COMMITTEE ON CONSERVATION, DEVELOPMENT, AND UTILIZATION OF NATURAL RESOURCES.

MR. M. N. BAKER. *Mr. President and Members of the Association,* — The committee has no very specific report to make. In fact, its name has been sufficient to weight it down so that it has been unable to do anything for several years past. You are all quite as familiar as are the members of the committee with the conservation movement, and nothing has come up which it has seemed necessary for the committee to lay before you at this time.

THE PRESIDENT. The next business is the report of the Committee "to prepare a Standard Specification for Fire Hydrants," Mr. H. O. Lacount, chairman.

MR. GEORGE A. STACY. Unfortunately, Mr. Chairman, Mr. Lacount is sick and unable to be present, but we expect a messenger from him with a document that we will desire to present, in addition to the report which has been submitted in print.

It is very unfortunate that just at the time when we have reached the climax of this long-drawn-out work the chairman cannot be here, for he has done a very large amount of the work.

THE PRESIDENT. We will pass the consideration of the report of the Committee to Prepare a Standard Specification for Fire Hydrants, and I will call for the report of the Committee "on Uniformity of Hose and Gate Nuts and Direction of Opening," Mr. Frank L. Fuller, chairman.

REPORT OF COMMITTEE ON UNIFORMITY OF HOSE AND GATE NUTS AND DIRECTION OF OPENING.

MR. FRANK L. FULLER. Mr. President, Mr. Lacount called me up about an hour before I left for this meeting in regard to this matter, and I told him that it seemed to me that the work of the Committee on Uniformity of Hose and the Direction of Opening of Hydrants and Gates was covered by the report which the Committee on Standard Specification for Fire Hydrants had made, and I think that is true. It seems to me that the Committee on the Uniformity of Hose and Gate Nuts, etc., has really done its work and ought to be discharged from further service, for if there is anything further in this matter it will come up under the work of the new committee.

On motion it was voted that the report of the committee be accepted and the committee be discharged.

THE PRESIDENT. The next matter is the report of the Committee " on Water Consumption and Statistics Relating Thereto," Mr. Leonard Metcalf, chairman.

REPORT OF COMMITTEE ON WATER CONSUMPTION AND STATISTICS RELATING THERETO.

MR. LEONARD METCALF. Mr. Chairman, I regret that your committee is not ready yet to make a report to you upon its work. We have gotten together quite a lot of material, but we regret to say that the material is not of the sort which we had hoped to get. I think all of you will appreciate the difficulties of the problem of getting records of this sort sufficiently comprehensive to be significant; and the committee — or at least I, for one — have come to the conclusion that we will be able to do more effective work — in fact, we think we can only present to you material of value — by taking the records of a certain number of plants, a few plants, and putting enough study on to those to get some fundamental facts.

Therefore, your committee asks that it may be continued another year, and takes this opportunity to ask that any of you who may feel that you have within your company records, or the records of the plant which you are operating, material which could be worked up at an expense of time and money, perhaps, but material which is available, you would advise the committee of this fact, so that we may see if we cannot put the necessary work upon plants where we know the material is available.

I might say that in the course of a trip abroad this last summer I made a number of inquiries along this line to see if statistics had not been accumulated abroad with regard to the division or character of water consumption. In Germany in particular I found that records were available concerning the public uses of water, but there they virtually stopped. There was none of the division as between a domestic consumption and a manufacturing consumption which we are after, at least so far as I was able to find; and, of course, conditions of life and the use of water in this country are so different from the conditions abroad that we ought to study the problem at home. So your committee asks to be continued another year, Mr. Chairman, if that is the pleasure of the Association.

THE PRESIDENT. I am sure we all are glad to hear that this important matter is going forward. I think no action is necessary to grant the continuance for another year, as asked for.

Next is the report of the Committee "to collect Information as to Low-Water Yields of Catchment Areas in New England, and, at their Discretion, Outside of New England," Mr. Frederic P. Stearns, chairman.

MR. HAROLD A. BARROWS. Mr. Chairman, the chairman of the committee has asked me to read this very brief progress report of the work of the committee, dated January 10, 1912.

Mr. WILLARD KENT, *Secretary*,
New England Water Works Association,
715 Tremont Temple, Boston, Mass.

Dear Sir, — The Committee on Yield of Drainage Areas has no extended report to make at this time, but can report substantial progress in accordance with the plan described briefly in the report of the committee made to you at the annual convention in September. Circular letters and blank forms were submitted to all the members of the committee on October 25, with the expectation of including information upon the yield of drainage areas through the year 1911, which, owing to the conditions of drought prevailing well into the season, it was necessary to include in the period covered by our investigations.

Preparation of data by members of the committee and other parties is well under way, but a further period of several months will be required in which to complete this work.

Very truly yours,
Frederic P. Stearns, *Chairman*,
H. K. Barrows, *Secretary*,
For the Committee.

The President. I think the work of this committee is one of the most important matters that the Association has in hand at this time, and while we want the result as promptly as possible, I think the necessary time to put the information in the best shape should be granted.

Mr. J. Waldo Smith then spoke of matters connected with the crossing of the Hudson River, giving incidents and figures concerning the investigation and progress of the work.

The President. Is the Committee to Prepare a Standard Specification for Fire Hydrants now ready to report?

REPORT OF COMMITTEE TO PREPARE A STANDARD SPECIFICATION FOR FIRE HYDRANTS.

Mr. George A. Stacy. Mr. President, we have heard from Mr. Lacount. He has sent a preliminary statement to accompany the report made by the full committee, with a request that it be read. Mr. Sullivan, a member of the committee, will now read the statement, which is in the nature of an historical sketch introductory to the printed report which is before you.

Mr. William F. Sullivan. I regret Mr. Chairman, that Mr. Lacount is not here to-day, because of illness, to make this statement, but it has just been handed to me to read. It is as follows:

"Two years ago this committee made a progress report and submitted a tentative set of specifications for post hydrants. A year later we reported that unexpectedly we had been unable to carry out certain tests as planned on present makes of hydrants, due to the fact that the manufacturers were unwilling to assist the committee by loaning sample hydrants for test, and it was recommended that the specifications previously reported be continued as the tentative specifications of the Association.

" Although we have not yet received any assistance from the manufacturers, we nevertheless have been able to obtain during the past year several hydrants for test, and from these tests, which have cost several hundred dollars to carry out, we have obtained some of the information desired. As a result of the further study of the subject, a few amendments of the specifications previously submitted have been found advisable, and we now present for your final consideration and adoption the specifications as amended, advance copies of which were sent to the members of the Association with the notice of this meeting. A copy of the specifications and notice of the meeting were also sent to each hydrant manufacturer of whom we had any knowledge.

" We wish to say also that these specifications have been sent to the hydrant committee of the N. F. P. A., and also American Water Works Association, and from the replies thus far received from the N. F. P. A. Committee and from previous interviews with chairman of the American Water Works Committee, it is believed that the specifications will meet the approval of both committees.

" We therefore trust that this Association will approve the specifications substantially as now submitted, to the end that there may be finally one standard hydrant specification for this country.

" H. O. LACOUNT, *Chairman*."

PROPOSED SPECIFICATIONS FOR POST HYDRANTS.
FINAL REPORT OF THE COMMITTEE.

1. SIZE.

a. The size of hydrants shall be designated by the nominal diameter of the net valve opening, which must be at least 5 inches for hydrants having two 2½-inch hose connections and 6 inches for those having three or four 2½-inch hose connections.

In hydrants having valve openings of shapes other than circular, the designation of size must be the diameter of the circle equal in area to that of the valve opening.

b. The net area of the waterway at the smallest part when the hydrant is wide open must not be less than that of the valve opening.

In new designs it is recommended that inside diameter of hydrants, especially at the outlets, be 7 inches and 8 inches respectively for hydrants having 5-inch and 6-inch valve openings.

c. Hydrants must be fitted with bell ends to fit New England Water Works Association standard pipe, or with flanges of standard dimensions and having standard bolt layouts, published jointly by the American Society of Mechanical Engineers and the National Association of Master Steam and Hot Water Fitters, as given in the following table. Holes are not to be drilled on the center line, but symmetrically each side of it.

Size of Pipe. Inches.	Diameter of Flange. Inches.	Diameter of Bolt Circle. Inches.	Number of Bolts.	Size of Bolts. Inches.	Flange Thickness at Edge. Inches.
2	6	4¾	4	⅝ x 2	⅝
2½	7	5½	4	⅝ x 2¼	11/16
3	7½	6	4	⅝ x 2½	¾
3½	8½	7	4	⅝ x 2½	13/16
4	9	7½	4	¾ x 2¾	15/16
5	10	8½	8	¾ x 3	15/16
6	11	9½	8	¾ x 3	1
7	12½	10¾	8	¾ x 3¼	1 1/16
8	13½	11¾	8	¾ x 3½	1⅛
10	16	14¼	12	⅞ x 3⅝	1 3/16
12	19	17	12	⅞ x 3¾	1¼
14	21	18¾	12	1 x 4¼	1⅜

Where working pressure is from 125 to 250 pounds, the standard for heavy flanges must be used.

2. GENERAL DESIGN.

a. Any changes in diameter of the water passage through the hydrant must have easy curves and all outlets must have rounded corners of good radius.

b. Hydrants must be so designed that with ordinary usage they will not cause water hammer.

c. Hydrants must be so designed that the leaded joint underground can be strapped.

In any new design it is recommended that the hydrant be so constructed that when the valve is shut it will remain tight when top of hydrant is removed or barrel is broken off.

3. MATERIAL OF BODY.

The hydrant body shall be made of cast iron of good quality, such as shall make the metal strong, tough, and of even grain. The strength of the cast iron must be that required by the specifications for standard cast-iron pipe 12 inches and less in diameter.

4. HOSE NIPPLES AND VALVES.

a. Hose nipples must be of bronze, threaded with a fine thread into the hydrant, and securely pinned in place.

b. Hose threads on all hydrants to be installed in any given community must of necessity be interchangeable with those already in service, but, where practicable, threads should conform to the 1906 National Standard adopted by the National Fire Protection Association. The essential features of the "National Standard" are a 60 degree V-thread, outside diameter on male threads of $3\frac{1}{16}$ inches and $7\frac{1}{2}$ threads per inch.

c. Inside hose-gate valves must have bronze working parts and be of rugged design and must not introduce an unnecessary friction loss. There must be ample clearance between the gate and the hydrant body when the gate is in any position. The gate and parts should be interchangeable and the valves should be located so as to be as accessible as possible for repairs. The gate must be designed so that it cannot come off in use. The top of the stem must be below the level of the hydrant stem nut so that the hydrant wrench can be freely operated. If outside hose-gate valves are used instead of inside valves, they must be of bronze or of iron with bronze trimmings, with lugs cast on the valve body, each valve must be bolted to the hydrant by two $\frac{3}{4}$-inch tap bolts, spaced $5\frac{5}{8}$ inches on centers. The valves must not project further than necessary and must be of the inside screw type, placed in a vertical position with the hand-wheel at least 3 inches below the base of the operating nut.

d. The stems of the hose valves must be not less than $\frac{3}{4}$ of an inch in diameter for the $2\frac{1}{2}$-inch valves, and not less than $\frac{7}{8}$ of an inch in diameter for the valves at the steamer connections.

e. The stem nut of the inside hose-gate valve must be $\frac{1}{2}$ of an inch square.

5. HYDRANT VALVE.

a. The seat must be made of bronze, securely fastened in place.

b. The valve must be faced with a yielding material such as rubber or leather except that if of the gate type a bronze ring may be used. The valve must be designed so that it can be easily removed for repairs without digging up the hydrant.

c. With gate type of valve, clearance of parts must be such that corrosion will not make the parts inoperative.

6. DRIP VALVE.

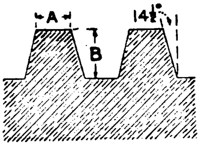
a. A positively operating non-corrodible drip valve must be provided and arranged so as to drain the hydrant when the main valve is shut.

b. The seat of the drip valve must be securely fastened in the hydrant. All other parts of the drip mechanism must be designed to be easily removed without digging up the hydrant.

7. OPERATING STEM.

a. The operating stem at the base of the thread where threaded, and also where it passes through the stuffing box and gland, must be of bronze not less than 1¼ inches in diameter. The bronze must have a tensile strength of not less than 32 000 pounds per square inch. The remainder of the stem may be of iron with cross-sectional area not less than 1½ square inches, except at couplings, where the area may be 1 square inch. The operating stem must be attached so that in operation it will be impossible for it to become detached.

b. The stem must terminate at the top in a nut of pentagonal shape, finished with slight taper to 1½ inches from .point to flat, except for hydrants to be installed where existing hydrants have different shape or size of nut, in which case the additional hydrant must have the same operating nut as the old ones for uniformity. The nut socket in the wrench must be made without taper so as to be reversible.



$$A = \frac{0.3707}{\text{No of threads per inch}}$$

$$B = \frac{1}{\text{Twice No of thds per inch}} + .01''$$

c. The thread which operates the valve must be Acme standard. See sketch opposite.

8. STUFFING BOX AND GLAND.

a. The stuffing box and gland must be of bronze or bronze-bushed. If a packing nut is used, it must be of bronze. The bottom of the box and end of the gland or packing nut must be slightly beveled.

b. Gland bolts or studs must be of bronze, iron, or steel, at least $\frac{5}{8}$ of an inch in diameter. The nuts must always be of bronze.

9. HYDRANT TOP.

a. The hydrant top must be designed so as to make the hydrant as weatherproof as possible and thus overcome the danger of freezing the stem. Provision must be made for oiling both for lubrication and to prevent corrosion. A reasonably tight fit should be made around stems.

b. There must be cast on the hydrant top, in characters raised $\frac{1}{8}$ of an inch, an arrow at least 4 inches long showing direction to open, and the word " Open " in letters 1 inch high.

10. HOSE CAPS.

a. Hose caps must be provided for all hose outlets, and must be securely chained to the barrel with a welded chain of wire not less than $\frac{1}{8}$ of an inch in diameter.

b. The hose-cap nut must be of the same size and shape as the stem nut.

c. A leather washer must be provided in the hose cap, set in a groove to prevent its falling out when the cap is removed.

11. MARKINGS.

Hydrants must be marked with the name or trade mark of the manufacturer, the nominal size, and the year of manufacture. All letters and figures must be cast on the hydrant well above the ground line. They must be 1 inch high and raised $\frac{1}{8}$ of an inch on the casting.

12. TESTING.

a. Hydrants must be tested to at least 300 pounds per square inch before leaving the factory. If the working pressure is over

150 pounds per square inch, the hydrants must be tested to twice the working pressure. The test should be made with the valve open in order to test the whole barrel for porosity and strength of hydrant body. A second test should be made with the valve shut in order to test the strength and tightness of the valve.

b. Hydrants must be fully opened and closed before shipping in order to test the freedom and strength of the parts. The conditions of the test should be made as severe as are liable to occur in service when using a hydrant wrench at least 17 inches long.

13. DIRECTION TO OPEN.

Hydrants must open to the left (counter-clockwise), except those to be installed where existing hydrants open to the right, in which case the additional hydrants must turn the same as the old ones for the sake of uniformity.

H. O. LACOUNT, *Chairman,*
GEORGE A. STACY,
FRANK A. McINNES,
FRED W. GOW,
WILLIAM F. SULLIVAN,
Committee.

The President. Gentlemen, you have heard this report. Before taking action on this important matter I think full discussion of it should be had, and I think it only proper to say that the associate members having to do with hydrants are entitled to take part in the discussion. The matter is now before you, gentlemen.

Mr. Samuel A. Agnew. Mr. President, considering the fact that I have talked with some of the hydrant manufacturers and they have expressed a desire to be called in conference with this committee, before it was decided just what should be done with regard to changing hydrants and adopting a standard specification, I am rather surprised to hear that they have given no assistance whatever.

I do not know that it is in order, but if it is I would suggest that a committee be appointed to confer with the manufacturers, so that the whole question may be threshed out with the men who certainly ought to know something about making hydrants.

As I understand, there are a good many minor changes suggested in this report, which would result in a considerable difference between the hydrants which are suggested and those that we are using at present. This will necessitate on the part of the water departments the keeping of duplicate sets of parts of different kinds of hydrants, which I should consider very undesirable. It is hard enough to take care of the hydrants we have and to keep on hand sufficient parts to keep the present hydrants in repair, without having to have a new set of hydrants and parts for them.

MR. SULLIVAN. Mr. President, I would say that this committee has already conferred with the manufacturers. We had one conference in Boston, and at that meeting the manufacturers said that they would continue to interest themselves in this matter, and that they would keep in touch with this committee. I do not know the reason why the manufacturers failed to coöperate and keep in touch with the hydrant committee. I know that Mr. Lacount, as the chairman of our committee, has given much time and thought to these specifications, and I know that on several occasions he gave the manufacturers an opportunity to come before the committee and discuss changes in the specifications.

As a member of the committee, I do not want to antagonize the manufacturers, and I think the committee as a whole is perfectly willing that the manufacturers even at this date should come in and confer with them. If another committee is appointed I do not see that there will be much need of the present one continuing along the lines upon which we have been working.

In order to bring the matter before the Association, which is the body to decide, and to bring it to your consideration so that you may act upon it, I move the adoption of these specifications as printed. I do not make this motion with the idea of rushing it through, but simply to give the members and the hydrant manufacturers who are here to-day in large numbers, an opportunity to express themselves and make known their objections.

I know the members of the committee are willing to meet the hydrant manufacturers on almost any ground. The committee's work has been simply to prepare a definite set of specifications, so that the members of this Association, or any purchasers of hydrants, may know exactly what is a 5-in. hydrant or a 6-in. hydrant and the hydrant's characteristics and efficiency, its strength, durability, and method of manufacture on lines similar to the New England Water Works Standard Specifications for Cast-Iron Pipe. I hope that the members and the hydrant manufacturers here to-day will express themselves, so that by this means, at least, the hydrant committee will be able to get some information and learn what the manufacturers and members want regarding these specifications. The final word, however, with regard to hydrant specifications must come from the Association. You, gentlemen, are the final judges, for you buy and pay for the hydrants.

Mr. Frank C. Kimball. I second the motion that we adopt the specifications.

The President. The matter is still open for discussion. I see several representatives of the manufacturers present, if I am not mistaken. Have they anything to say upon the subject? Are they satisfied with the specification, and if not, what changes do they desire?

Mr. Charles R. Wood. Mr. President, I have been asked by some of the manufacturers to speak for them on this subject. I will say that while we had some conferences with the committee we never had any particular standing as a body in any way. The manufacturers with whom I have discussed the matter seem to think that if the Association would appoint a committee, say, of five manufacturers who were interested in the manufacture of hydrants and associate members of the Association, to meet with Mr. Lacount, Mr. Sullivan, Mr. Stacy, and Mr. McInness, we might cut down the small differences which exist in the specifications as they are presented here to-day. These suggested specifications — I notice they are marked "Subject to revision" — differ greatly from the last set that were published, and, of course, the manufacturers have not had a chance — I think Mr. Sullivan will bear me out in this — to take up with the committee the changes which have been made. The manufacturers would like very much to have a committee appointed from the associate members who are interested in making hydrants, so they would have at least some standing, perhaps with the addition of some officer of the Association, the President or some one, to make a little more formal matter of it, to take this matter up with your committee.

On the question of submitting hydrants for test, a number of us did agree to submit hydrants for test, and a number of us had them ready to send, with the idea that the test was for the purpose of showing the flow of water for the various sizes of valve openings. When we asked, however, what tests were going to be made, we were told that they would do whatever they wanted with the hydrants. I do not know whether that report came from the full committee, or whether it was a report to us individually, or whether every manufacturer was told the same thing; but we were told that our hydrants would be tested in any way the committee liked, whereas the original idea the manufacturers had was that they would be tested for the flow of water through the body of the hydrant.

We would be very glad to have representatives of the manufacturers, say five, the same number as the present committee of the Association, or whatever number you may think proper, take the matter up in detail, because there are but a very few things with which the manufacturers are not entirely satisfied in the specifications as they read to-day.

THE PRESIDENT. Is there any other statement to be made by any of the manufacturers?

MR. WOOD. Mr. Chairman, I was asked to speak for most of the manufacturers present. It did not seem necessary for all of us to talk along the same lines, but there are a number of manufacturers here, if the Association wants to hear from them.

THE PRESIDENT. The matter seems to stand in this way: We have a specification which has been prepared by a most competent committee, which, I take it, meets for the most part the approval of the manufacturers, but the manufacturers want some changes made in it. I have no idea what the character of those changes may be, but it seems that it would be well, perhaps, to defer action until a conference could be had along those lines. What do you say, Mr. Sullivan?

MR. SULLIVAN. Mr. President, in regard to the revision of these specifications from the previous draft, I would say that most of the revision was done from suggestions made by the manufacturers. Now, I presume that in the main these specifications are satisfactory to all parties; and I would offer a suggestion, although I have made a motion and it may not be in order at this time, that these specifications be gone over rapidly by sections or by items, so that we may find out what items do not accord with the ideas and practice of the hydrant manufacturers. Of course the Association has the authority to appoint an additional committee to meet with the present hydrant committee, and I do not think any member of the hydrant committee will object to that. It seems to me, however, as this thing has been hanging fire for several years, we might be able to clear it up more quickly by having the hydrant manufacturers who are here express their views now. I earnestly suggest that this matter be taken up, and that the hydrant manufacturers point out what items or what sections in the specifications they object to.

MR. WOOD. Mr. President, we have had these specifications in our hands only four or five days, and we have not had time yet to discuss the matter thoroughly among ourselves. We would like, rather than to go into detail as to requests for changes in the specifications at present, to have a chance to confer among ourselves, and then to confer with the committee. There may be some suggestions which it will not be necessary for us to make, when we know all the reasons which the committee have for suggesting certain paragraphs in the specifications.

THE PRESIDENT. It seems to the Chair that there is no occasion for a change in the committee; that our present committee can handle this matter as well as any that can be appointed; and it seems to the Chair, further, that the manufacturers are well organized and well represented, and that they can present the matters that they have in mind to the committee, and that the committee can consider them and report back to the Association at a very early date. It would seem to the Chair that this would be the wisest solution of the problem. There is a motion before you, gentlemen, to the effect that these specifications be adopted. Is there any further discussion?

MR. FRANK L. FULLER. Mr. President, I would like to ask the committee in regard to a point which, perhaps, is one of minor importance, but on page 80, in speaking of the operating stem, it says it shall be " finished with slight taper." Then, further on, it says: " The nut socket in the wrench must be made without taper so as to be reversible." I think the fire underwriters prescribe that the operating stem shall be without taper, and also that the nut on the wrench shall be without taper. It seems to me that if there is a taper on the stem there should be one in the wrench, and I would like to ask the committee what the object is in having the wrench without taper and the stem with taper.

Mr. George A. Stacy. A hydrant wrench is liable to be used either side up, and I do not see how you could have a taper in your wrench unless you had it marked and could be sure that the firemen were going to have it that side up all the time. The taper on the nut makes it a little easier to fit the wrench on, as a man rushes to a hydrant to open it, in the excitement of a fire. It is not correct mechanically, perhaps, but it is practically. If the hydrant nut fitted the wrench the whole way, it would be difficult to get the wrench on under the conditions that exist at a fire. Another factor which enters into the problem is the small boy with a stone for a hammer. If the wrench fits tight all the way down on the nut, it takes but a few minutes for a small boy to fix the nut so that you cannot get the wrench on, without some trouble. They do that sometimes in the best communities. Now, if you have got a little taper on the nut, and you have got a little leeway in putting your wrench on, a man will fit it more quickly, and you will get sufficient bearing on the base, where it will fit closely, so that you will have sufficient bearing to operate it without any trouble.

Mr. M. N. Baker. If it is in order, Mr. President, I would like to offer a substitute for the motion before the Association, to this effect: That the associate members interested in the manufacture of hydrants be requested to confer with this committee on the subject, and that the committee report to the Association at a later date.

It seems to me that will perhaps clear the ground. I offer it merely as a suggestion to aid in getting the matter straightened out.

The President. Mr. Sullivan's motion is for the immediate adoption of the specifications as they stand. Mr. Baker's substitute is to request the associate members to confer with the committee, and to request the committee to report again to the Association.

Mr. Sullivan. Mr. President, I am willing to withdraw my motion for the adoption of the specifications. I made the motion so as to get the specifications discussed. With the permission of the gentleman who seconded my motion, and if there is unanimous consent, I withdraw my motion for adoption.

We have with us to-day Mr. Teague, who is an assistant to Mr. Lacount, our chairman; he can give you some data regarding the hydrant tests. He is not a member of the Association, and I respectfully ask that the privileges of the floor be extended to him to speak regarding the hydrant tests while the members are here, so they can better know what the committee's ideas were in making these tests.

The President. Do you suggest that he speak to us before the disposition of the matter which is now pending, Mr. Sullivan?

Mr. Sullivan. I withdraw my motion.

Mr. Kimball. I will withdraw my second.

Mr. Waldo Smith. I thoroughly agree, Mr. President, that the consideration of this matter should be postponed. I know that there are a great many engineers and water-works superintendents here to-day who feel that there has not been sufficient time since this report has been out to consider it. The first of the year is a very busy time, and a great many of us have not had time to consider this report. I am in favor of Mr. Baker's motion, except I believe it would be wiser, instead of leaving it to the manufacturers to get together as a whole with this committee, to have the President of the Association appoint a committee of the manufacturers, not a large number, whose business it will be to learn the views of the rest of the manufacturers and confer with the committee. That is the only difference of opinion I have with Mr. Baker; but it seems to me that perhaps the matter can be handled better in that way than by leaving it to all the manufacturers.

The President. What do you say on that point, Mr. Wood?

Mr. Wood. That was the original suggestion that we made, that the President of the Association appoint a committee of five, because there were five on the other committee, and that would seem to be a sufficient number to make up the committee. That would be very satisfactory to the manufacturers. The number of the committee might be left to the discretion of the President.

The President. Of course under this arrangement those men would not be members of the committee. It would be their duty to present the manufacturers' side of the case to the committee.

Mr. Wood. Certainly.

Mr. Baker. I am perfectly agreeable to that, Mr. President, if that is the idea of the Association. It does not make any difference whatever to me how it is got at, as long as the end is achieved.

Mr. Stacy. Mr. President, I think I can say there is no objection on the part of the committee to this conference. From start to finish we have only been anxious to get the best there was to get, and we have felt that we needed all the knowledge that there was in the business. We certainly concede to the manufacturers that they know something about hydrants, and the conference we had was a valuable one, although we were considerably apart on some things. While this matter has been dragged along, I think it is the desire of the committee that when the work is completed it should stand on solid ground, and that, as far as it is possible for human minds to agree, we should all agree that these specifications are the best for all parties that can be drawn up with our present knowledge.

The President. I take it that the manufacturers will be prepared to act promptly on this, Mr. Wood?

Mr. Wood. At the call of the chairman of the committee.

Mr. M. S. Kahurl. Mr. President, I would like to ask a question. We are manufacturing hydrants, and how will those of us stand who are not appointed on the committee? Will we be entitled to the information that is to be given to and from the committee?

Mr. Wood. As far as the manufacturers are concerned, we shall be only too glad to get suggestions from any manufacturer of any hydrant, and all the information that we would have would be given out, and presumably all the information which the committee received would be given out to any manufacturer who wanted to know about it.

THE PRESIDENT. It is the feeling of the Chair that the best results would be obtained by allowing every manufacturer to go to the committee with all the "kicks" he has to make, and allowing every member of the Association to go with his.

MR. BAKER. That was my idea in suggesting, as I did, that the associate members who were interested in the subject be asked to confer with the committee, so that they could all have a chance. If they want to organize a subcommittee to take up the active work, that is within their power.

THE PRESIDENT. The question, I believe, is on Mr. Baker's motion.

MR. M. F. COLLINS. Before that motion is put, Mr. President, Mr. Sullivan has suggested that there is a gentleman here who wants to give some statistics on hydrant tests. It will only take a few minutes, and I hope the gentleman will have a chance to tell the Association what he has to say with regard to that matter.

THE PRESIDENT. I was planning to give him the floor, Mr. Collins, directly after putting this motion.

(Mr. Baker's motion that the associate members interested in the manufacture of hydrants be requested to confer with the committee, and that the committee report to the Association at a later date, was adopted.)

W. O. TEAGUE, Esq. Mr. President, I think what I have to say will not be so much to the point now as it would have been previous to the adoption of the motion which has just been put.

I wanted to say a word about the purpose of the tests which were made. The first draft of the specifications that was gotten up met the approval generally of the manufacturers, except as regards the size of the valve opening in the hydrant. The committee, as you remember, specified a 5-in. opening, — in other words, an area corresponding to a 5-in. diameter circle, — for a two-way hydrant. The question was raised as to whether this was necessary or not. In order to settle that, it was necessary to make tests. We endeavored to get hydrants for this purpose from the manufacturers, but were unable to do so. We then, as was stated by Mr. Lacount, got some representative hydrants, and made tests on them, with the result that we showed conclusively that for a two-outlet hydrant a 5-in. valve opening is advisable. It seemed to us that that settled the main objection which the manufacturers had to the specifications as written at that time.

In addition to the tests, we made slight revisions in the draft of the specifications, to cover as far as possible the points — or objections you might call them — raised by the various manufacturers, so as to cover their particular design of hydrant without necessitating changes. Of course that could not be carried to an extreme and have the specifications suit all the hydrants that are made to-day. The best that could be done was to have pretty general specifications, representing the best conservative practice of the day in hydrant construction. For that reason it seems to me that the specifications as now before you are in final form, and that there are no vital points which need further consideration.

As I understand it, the purpose of the hydrant committee was, first, to recommend a basis for the designation of the sizes of hydrants. This has been done. In addition, it was the purpose of the committee to prepare a standard for good design, good construction, good workmanship, durability of parts and serviceability of the hydrants. We feel that the specifications as now written cover all these points, and it does not seem that further discussion of the matter with the hydrant manufacturers is going to lead anywhere. It simply means a delay. This work has been carried on in conjunction with the work which the Factory Mutual Fire Insurance Companies are doing along a similar line in connection with mill yard fire hydrants, and in view of that the committee has had the benefit of all the knowledge and data which the Mutual Companies have on the subject.

The thought in outlining these specifications was to have the hydrant in the street the same, or as nearly as possible the same, as that in the mill yard. We found finally that the only real difference that was necessary was in regard to the independent gate. The hydrant in the street should, of course, have inside gates, since the outside hose gates form an obstruction and are apt to be broken off, whereas for mill yard use the outside gates are preferable. That feature is covered in the specifications as presented here.

In connection with the tests which were made for friction loss in hydrants we had intended to include in the specification a reference to the results; and in order that this may be made a matter of record I would like to read an abstract from Mr. Lacount's letter to the members of the committee, or, rather, the committees of the several associations, — that is, the New England Water Works Association, the American Water Works Association, and the National Fire Protection Association.

" It is proposed that the following be inserted in Article 2 on page 78: '*b.* With the hydrant discharging 250 gallons per minute through each 2½-in. hose outlet, the total friction loss of the hydrant shall not exceed two pounds for two-way, three pounds for three-way, and four pounds for four-way hydrants.' "

This will of course advance the lettering of articles *b* and *c* to *c* and *d* respectively. As regards the maximum allowable friction losses specified in this item, we wish to say that these are considered very liberal, in view of the results that were obtained in the tests; that is, that with very little change in the average hydrant as made to day, such as rounding outlets and having good surfaces, the average hydrant could come well within this requirement. We did not think it advisable to endeavor to cut this allowable loss down too fine because we did not know where to stop. It is possible that later on these figures can be revised to some extent, but for the present, in order to get some working arrangement, it is proposed that friction losses as specified be allowed.

I have nothing further to say on the matter except that Mr. Lacount and myself are very confident that the work has been carried to such a point that no material improvement of the specifications can be expected from a further discussion or consideration of the details with the manufacturers, and for this reason we hoped that the specifications would be adopted as presented.

Mr. Leonard Metcalf. Mr. President, might I through you make one suggestion to the committee in regard to these specifications, which is suggested by a casual reading of them, and that is that they should be self-contained, so you will not have to refer to any other document to have your full specification. I notice that in paragraph 3 the second sentence reads: "The strength of the cast iron must be that required by the specifications for standard cast-iron pipe 12 in. and less in diameter." Wouldn't it be desirable to have this requirement embodied in these specifications, so that in reading the specifications you have the entire thing before you?

Mr. Sullivan. Mr. President, I remember that point was discussed at one of our meetings, and it was thought that embodying the New England Water Works Specifications for Standard Cast-Iron Pipe would make these specifications rather long; but I think the suggestion of Mr. Metcalf is good, and I do not know but it is the best thing to do.

Mr. Charles E. Chandler. Mr. President, may I make one suggestion, at the request of the chief of the Fire Department of Norwich, Conn.? Under "Hose Caps," paragraph *c*, it reads: "A leather washer must be provided in the hose cap, set in a groove to prevent its falling out when the cap is removed." Our chief, Mr. Stanton, is of the opinion, and I beg the privilege of suggesting here, simply for the consideration of the committee in their further work, that a babbitt-metal washer that will not dry up and fall out, as leather washers do, might be an improvement over the leather washer. He has had a sketch made according to this idea, which I would be glad to have any of the members, and especially the manufacturers, look at, and if they should find any great difficulties in relation to the matter, of course they would not need to consider it further. But if it should prove, as Mr. Stanton thinks, that the babbitt-metal washer would be more effective and no more expensive, the object of this suggestion would be accomplished.

Mr. Sullivan. Mr. President, that matter was taken up while we were having a conference with the hydrant manufacturers. I know it was discussed *pro* and *con* very thoroughly. The object of the leather washer was that when there were several outlets to a hydrant, and only one line of hose attached, and no independent gate-valves, the water would be kept from spurting from the unused outlets and wetting the hydrant man who was operating the hydrant. But that is only a small detail, and I know the committee will be willing to consider it, although the leather washer was the outcome of the joint conference between the committee and the manufacturers.

MR. A. E. MARTIN. With regard to the leather-washer business, a year ago in Springfield we changed all our hydrant screw threads so that there should be no washers at all. We now use them plain without a washer, and we have no trouble in keeping the water from running out of the nozzles. They never leak at all; they are made very tight and metal faced.

MR. CHANDLER. May I ask if there is any corrosion of the metal and sticking of the cap at times?

MR. MARTIN. We never have had a particle of trouble so far. Of course we have only been using them a year, but before I went to Springfield I used hydrants in the same way for eighteen years, and I never had any trouble with them.

THE PRESIDENT. This is a most interesting and profitable discussion, and it is to be hoped that it may be continued when the specifications are reported back, and when certainly it is to be hoped they may be finally adopted and the business thus be standardized, as other branches of our work have been standardized.

PRESIDENT'S ADDRESS.

Gentlemen of the New England Water Works Association:

The past year has been, in most respects, one of quiet work and with no unusual events. In membership, there has been but a slight gain, the new members elected only slightly exceeding in number those lost through various causes. Financially, the Association has held its own, and the treasury is believed to be in satisfactory condition. These matters are set forth in the reports of the Secretary, Treasurer, and Editor, — which you have ust heard, — and do not need to be now repeated.

The deaths of ten of our members have been reported since the last annual meeting, namely:

		Elected to Membership.
John T. Fanning,	Civil Engineer, Minneapolis,	1885
Amos A. Gould,	Water Commissioner, Leicester, Mass.,	1896
C. A. Hague,	Civil Engineer, New York City,	1904
L. E. Hawes,	Civil Engineer, Boston, Mass.,	1888
L. P. Kinnicutt,	Chemist, Worcester, Mass.,	1893
A. R. McCallum,	Superintendent Water Works, Whitman, Mass.,	1906
C. W. Paine,	Civil Engineer, Highland, Cal.,	1888
W. H. Sears,	Civil Engineer, Plymouth, Mass.,	1899
Wm. H. Thomas,	Superintendent Water Works, Hingham, Mass.,	1887
W. P. Whittemore,	Chief Engineer Water Department, Attleboro, Mass.,	1886

From a physical standpoint, the year has been an interesting one, as the third in a cycle of dry years. The first part of the year was particularly dry, and, following two dry years, the deficiency in rainfall brought about conditions that were serious in many water-supply systems, especially where the catchment areas were small for the reservoir capacities.

This dry period, which now fortunately seems to have passed, has been one of the most notable that has occurred in New England since accurate records have been available.

One of the most important events of the year was appointing a committee by the Association to collect data as to this and other dry periods, and to study the whole subject. This committee is not yet ready to report, but it is believed that information will be obtained which will serve for many years as a basis for estimating the capacity of water supplies in New England.

It is nearly thirty years since there has been a record-making drought, and in this interval the records of the Sudbury River and a few other streams in the years following 1880 have been used as a basis for nearly all such calculations.

There is some reason for believing that earlier in the nineteenth century there was a drier period than that of the eighties, but records are inadequate.

When this report is available, it may be appropriate for the Association to discuss the question as to how far a practical rating of water sources should be based upon the records of the driest year on record. Dry years may be classified according to the frequency with which they recur. There is a degree of dryness that is reached on an average once in ten years, and another reached on an average once in thirty years, the latter represented approximately by the dry period of the early eighties, and again by the dry period of the last few years. Presumably, there will be still drier years, which may be referred to in a general way as occurring not oftener than once in a century.

On the other hand, a water-supply system is seldom drawn to its ultimate capacity, and in fact can be but seldom so drawn with safety, because the consumption is always fluctuating, and enough water must be on hand to cover fluctuations and reasonable increases in rate, and in order to do this there is ordinarily some surplus capacity.

It may be questioned if it is justifiable as a practical business proposition to rate supplies on the droughts that only occur once in a century, or even on those which occur only once in thirty years, and whether it would not be better to take some less extreme basis, which basis could be established by proper records, and the limitations of which should be frankly recognized by writing them into all descriptions, and into the headings of tables.

For a city to be out of water is serious business. To be a little short one year in thirty may not be an intolerable condition, and it may be better business to have this happen than to build a whole water-works system so large that its capacity may only be needed once in thirty years.

Let us say, for example, that we will take some shorter period as a basis, such as ten years, and calculate the amount of water which can be certainly supplied nine years out of ten, and on an average in the tenth year, and take our chance on being a little short once in twenty or thirty years, if it so happens that the full rated capacity would be then used if it were available.

Following out this idea and developing it somewhat, it might be stated that a certain water supply was good for so many gallons per day four years out of five, for so many nine years out of ten, and for so many twenty-nine years out of thirty. Each figure for capacity in this series would be somewhat smaller than the preceding one, and the ratios between them could be fixed with a fair degree of accuracy. We should then have a better idea of what chances we were taking, and what rating it was wisest to adopt.

It is the custom for the President to speak to you at the annual meeting upon some serious matter. Last year, our President gave us a most interesting survey of the whole field of water-works business throughout the civilized world. To-day, I choose a narrower subject, namely, the management of water works. I shall refer particularly to water works under municipal ownership, and I wish to consider the matter along somewhat broad lines.

The ownership and operation of water works by cities is a kind of municipal trading. That is to say, it has nothing to do with government, but is, on the other hand, engaging in private business by a public body, which business might otherwise be performed by private parties.

A public enterprise of this kind is always something of an experiment. There are cases where notable success has been achieved. We all agree that our Post-Office Department is, on the whole, well managed and gives better service than could be anticipated from private ownership. In European countries, the telegraph is managed by Government, and the service is generally cheaper than it is with us; but on the other hand, there are rumors of deficits in the Government telegraph accounts, and, so far as they occur, the taxpayers are making up for the lower charges on the messages. It is claimed that the privately owned telephone system in America is more efficient than any publicly owned system in the world.

We have not yet taken up government ownership of railroads (except in the unusual case of the Panama Railroad), but much has been done in this direction in Germany and other European countries, and in other parts of the world, including Canada and Mexico. Some excellent results have been achieved, but I think that most of us hold to the belief that company management of railroads is more appropriate and, on the whole, more efficient than government ownership.

In Europe, gas works and electric-light plants are frequently owned by municipalities, and in a few cases American cities have taken up these lines of trading.

In the beginnings of the water-works business in America, private companies played a large part, and many important works are still owned by companies; but as time has gone on, more and more undertakings have passed into public ownership, until a great majority of water-works plants are now owned by municipalities. In general, the management of publicly owned water works has been good, and has produced results satisfactory to the water takers, and not burdensome to the taxpayers. No doubt mistakes are made in municipally owned works, and some of these would be avoided by company management, but I doubt if the losses growing out of them would exceed those to be reasonably expected with private ownership of corresponding works.

Taking it right through, the public ownership of water works has been the most successful line of municipal trading thus far undertaken by American cities.

One fundamental reason for this is that the water-works business is naturally profitable. The income is easily and certainly collected, and is regular from year to year. Water can generally be secured and furnished at so small a cost that rates may be at once remunerative to the system and not burdensome to the takers. It has thus been possible in American cities to collect all necessary money to conduct the business, and it has rarely been necessary to burden the taxpayers in supporting these undertakings. These conditions have made it easy to operate plants without incurring deficits and with general satisfaction to the citizens, and have perhaps lead to easy-going ways in some matters, where better business methods might have been adopted.

I propose to talk to you to-day about this general subject, and see if we cannot do something toward getting better methods adopted by the works with which we have to do. I know that some of you have already done a great deal in this direction, and methods of management have been introduced which are admirable, as relating to particular parts of some systems.

There was presented to us two years ago* an excellent paper on depreciation as applied to the water-works business. Discussion brought out the fact that must have been known to nearly all of us, that systematic calculation and allowance of depreciation charges is rarely carried out in publicly owned works. It may be said, also, that privately owned water works have, as a rule, neglected to make systematic depreciation charges until during the last years, when the regulation of such corporations and decisions of the courts as to reasonableness of rates, have made them imperatively necessary. It is now recognized that in the financial management of a privately owned water plant, the annual depreciation must be carefully calculated and allowed each year, and there seems to be no reason why corresponding calculation and allowance should not be made for a plant that is owned by a municipality.

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*JOURNAL N. E. W. W. A., Vol. 24, p. 305.

The reform in regard to depreciation charges is a most important one, but it is only one of a whole series that might be made with advantage.

Take the case of profits, or the return upon the invested capital, or, in the case of an old plant, on the fair value of the property. I think it is often true that the water-works management is satisfied if a balance is left in the hands of the treasurer at the end of the year, after operating expenses and the interest on the bonded debt have been paid, and perhaps some money put into extensions. But is this the whole question? Why should not a plant earn a fair return on its value, regardless of the amount of its indebtedness?

There are cases where the bonds originally issued to pay for water-works construction have been paid off, where additional construction has been paid for from earnings, and where the department is free from debt. There are other cases, fortunately less common, where bonds have not been paid off, where the works are depreciated, and where the plant is not worth the amount of the bonded indebtedness. Most plants lie between these extremes.

Let us consider for a moment the case of the plant that is out of debt. It is possible to operate the plant so as to pay its way, and to make water rates so low that they will cover only operating expenses and such other general expenses as have to be met, and water may be supplied at much less than cost.

Some people believe, no doubt, that this is the best way to manage the business, and that when works have once been paid for, the public may properly be given the benefit of this condition, and supplied with water at whatever rates less than cost prove to be feasible.

I am disposed to take another view of the matter and to hold that no water-works system can be called really self-supporting that does not earn a reasonable return upon the whole value of the plant, regardless of its bonded indebtedness. Certainly, the rates that will suffice to make such return are as low as rates could be made if the business were now being taken up for the first time, and in case the rate of return or percentage on the capital is as low as is consistent with good municipal management, the rates reached under this condition may be taken as representing the real cost of the service.

If a city has, by good management, or in any way, acquired a property which is valuable, and is capable, at fair rates, of producing a net revenue representing a fair rate of return on its value, is it not the duty of the municipality to manage it as any other owner of a trading enterprise would do, to secure the fair return that naturally grows out of the business, and use that return for the benefit of the citizens in any way that is proper? This view largely prevails in American cities, although it is not frankly recognized. There are many cases where the water revenue is turned into the general funds and serves to diminish the amount of money raised by taxation. There are cases where bridges and other municipal structures having no relation whatever to water works have been built with water-works money.

What I suggest to you to-day is, that this matter of accounting, which in the past has been of a most haphazard character, should be reduced to a definite basis, and standardized in accordance with sound business principles, but without defining too closely the rates of return that are to be earned, which I think should properly be left to the good business judgment of those having to do with the matter from time to time.

Then there is the question of taxation and free water. Why should public trading be done on different principles from private trading? Why should a water works be exempt from taxation, and why should the water works furnish free water for hydrants, schoolhouses, churches, and all other public and quasi-public institutions? Probably the underlying idea in many cities has been that the taxes that would otherwise be paid might be taken as an offset for the free water furnished to the city, and that the two things would balance each other, and that it would save bookkeeping to let matters go without calculation.

But this certainly is not a good business basis. Why should not the water-works plant be assessed taxes on its reasonable value, and why should not collection be made for all the water and services that are rendered?

The Interstate Commerce Commission has done away with dead-head transportation upon railroads. This action was a wise one, for the pass system had been atrociously abused. It meant a drain upon the railroads that could only mean higher fares for those who paid. But were the passes upon the railroads more abused than the free-water arrangement is abused in the case of municipally owned water works? If passes are abolished on the railroads, why should not dead-heads be abolished in the water business? Certainly, because a taker is another department of the city government, it is not sufficient reason why it should be supplied with free water.

On the railroads in the old days, it was, no doubt, true that those who had passes caused more trouble and expense than other travelers. So, I think, in your water departments, you will find that the dead-head takers are, in general, those who waste the most water, and that it costs the most to take care of. That which costs nothing is treated with but little respect. The schoolhouses that are furnished with free water will use gang closets or self-flushing closets to save a little money in plumbing, and the water will go pouring through them day and night, because the janitor has not sufficient interest to shut them off at night because it costs nothing.

Our water-works statistics relating to physical matters have been well standardized. Would it not be worth while to extend our form to include information as to the value of properties, the amount of depreciation allowed, taxes paid and free water furnished, the net earnings, and the per cent. which these are of the values? To find out the facts is the first step. The laws and ordinances that will provide for bettering the conditions may be logically expected to follow.

One reform that might naturally grow out of consideration of the business along these lines would be better and more uniform schedules of water rates. I do not believe that there is any other line of business that has such great and unreasonable variety in its schedule of charges as will be found in water works.

We have had committees on water rates, and a great deal has been done to straighten up and eliminate these eccentricities, but much remains to be done. The business cannot be considered to be in satisfactory shape in any given case until a serious effort has been made to find out what revenue is really required and to prepare a schedule of rates that will distribute that amount as fairly as it can be distributed, among all the different takers, keeping in mind reasonable limits of simplicity.

There are several different ways of approaching this subject that have merit. Following different ones in different cases results in rates that are not easily compared with each other. I suggest that it ought to be possible at this time to agree upon a general form of water rates that could be used in all cases, but with figures omitted, with the idea that they would be fixed in individual cases, to meet the requirements of the revenue to be produced, and the relative abundance or scarcity of water. Where water is relatively abundant, a larger part of the amount to be raised will naturally be placed upon the fixtures, and upon the privilege of having connection and having water available. Where water is relatively scarce, the amount to be raised will be proportioned in greater measure, or even altogether upon the quantity of water taken by the various consumers.

Such a uniform schedule might be similar in its general form to the schedules with which we are all familiar. Under fixture rates, there would be specified all the fixtures that would be charged for, and the method of rating them would be defined once for all, but leaving the amount of charge to be made for each item to be determined according to the requirements of particular cases. Under meter rates, the point would be settled whether the gallon or the cubic foot was to be the basis of the calculation, whether minimum rates were to be used, or whether, instead, a fixed charge should be made for the service, as recommended by our committee some years ago, with an additional charge for all water used, and the question would be taken up as to whether the scale should slide, and if so, at what points, and those points would be fixed; but the rates for water, and for the minimum charges, or for service charges would be left to be fixed according to the requirements of each case.

Schedules made up in this way could be directly compared with each other, which is something that cannot be done with present schedules of water rates, except in rare cases, as all of us know who have had to do with the rates, when effort has been made to investigate them by judicial procedure.

I may mention another question in water-works management, that arises in the case of cities or towns lying close together, and supplied most conveniently from one system. Cases of this kind are always numerous, and are especially so in the more densely settled parts of the country, as in New England. There is the case of the suburbs of a larger town, and the case of several towns lying near together, where the most available source of supply is at some distance, and where a single system would best serve all. This is a phase of water-works business where municipal ownership, up to the present time, has been relatively weak. The company form of management has had a distinct advantage under these conditions, because it knew no city lines and could use one system, as far as it was physically advantageous to do so.

In Maine, water districts have been formed, the boundaries of which followed the limits of the territory that could be conviently supplied with one system of works, rather than political boundaries. This plan has also been used in other places in America, in Europe, and quite generally in Australia, and it has been, on the whole, one of the most successful means of dealing with this phase of the question.

The Metropolitan water district here in Boston is, perhaps, the most conspicuous case of a successful solution of this problem, but in this case the state took a hand, so that the works as they stand are quite as much a state affair as a municipal undertaking.

In other cases, especially in the case of suburbs, the works of a city have been extended in adjoining country, or water has been sold wholesale. In other words, the municipality has been given leave to extend its trading beyond its own boundaries. Arrangements of this kind have been frequent, and are likely to be still more so, and in case one of the towns greatly predominates in size over the others, there is much to be said in favor of this arrangement. But there are many other cases where several municipalities have independent works, and are so situated that, physically, one system would better serve than several independent ones. The water problem may be the only one that draws these particular municipalities together, and coöperation between them in the line of economical development is often difficult or seemingly impossible. This is one of the most interesting problems to be solved in the question of municipal ownership.

ELECTION OF OFFICERS.

THE PRESIDENT. There remains only one item of business to complete the year's work, and that is the report of the tellers. Are the tellers ready to report?

MR. SAMUEL A. AGNEW. The tellers appointed to canvass ballots for the election of officers for the ensuing year submit the following report:

President.	
GEORGE W. BATCHELDER	301
Vice-Presidents.	
J. WALDO SMITH	292
FRANK A. MCINNESS	302
MILLARD F. HICKS	298
JOHN H. COOK	301
MORRIS KNOWLES	300
ROBERT S. WESTON	301
Secretary.	
WILLARD KENT	304
Treasurer.	
LEWIS M. BANCROFT	304
Editor.	
RICHARD K. HALE	303

Advertising Agent.

GEORGE A. KING	306

Additional Members of Executive Committee.

GEORGE A. STACY	301
JOHN J. KIRKPATRICK	301
RANDOLPH BAINBRIDGE	299

Finance Committee.

ALBERT L. SAWYER	301
FRED D. BERRY	299
JOHN W. MORGAN	301

The President thereupon declared the above-named gentlemen to have been elected officers of the Association for the ensuing year, and requested Mr. George A. King to escort the newly elected President to the chair. Addressing Mr. Batchelder, the retiring President said: I pass you, sir, the gavel, and congratulate you upon your election, wishing you and the Association all success during the year which begins with this act. [*Applause.*]

THE PRESIDENT. *Mr. Hazen and Gentlemen of the New England Water Works Association,* — I esteem it a great honor to have been elected as your President, and I shall make it my earnest effort during the coming year to advance your interests in every possible way in which I can. The success of any association depends very largely upon the coöperation in action of its members and its officers, and I sincerely trust that we shall all act together this year. I expect to receive the support and assistance of the other officers, of the committees, and of all the members, so that 1912 may be made a year of progress for the New England Water Works Association. I thank you, gentlemen. [*Applause.*]

Adjourned.

FEBRUARY MEETING.

HOTEL BRUNSWICK,
BOSTON, MASS., February 14, 1912.

George W. Batchelder, President, in the chair.

The following-named members and guests were present:

HONORARY.

Frederic P. Stearns.

MEMBERS.

A. S. Agnew, C. H. Baldwin, G. W. Batchelder, J. W. Blackmer, George Bowers, Dexter Brackett, E. C. Brooks, I. W. Brooks, G. A. Carpenter, George Cassell, J. C. Chase, R. D. Chase, M. F. Collins, A. W. Cuddeback, A. O. Doane, E. D. Eldridge, G. F. Evans, C. R. Felton, F. F. Forbes, F. L. Fuller, F. J. Gifford, A. S. Glover, Clarence Goldsmith, J. M. Goodell, F. H. Gunther, R. A. Hale, R. K. Hale, F. E. Hall, J. O. Hall, T. G. Hazard, Jr., H. G. Holden, J. L. Hyde, W. S. Johnson, E. W. Kent, Willard Kent, G. A. King, J. H. McManus, N. A. McMillen, W. E. Maybury, John Mayo, H. A. Miller, F. L. Northrop, T. A. Peirce, Dwight Porter, P. R. Sanders, A. L. Sawyer, G. H. Snell, G. A. Stacy, T. V. Sullivan, W. F. Sullivan, H. L. Thomas, R. J. Thomas, L. D. Thorpe, J. L. Tighe, J. A. Tilden, E. J. Titcomb, C. H. Tuttle, W. H. Vaughn, L. J. Wilber, F. I. Winslow, G. E. Winslow, I. S. Wood. — 62.

ASSOCIATES.

Anderson Coupling Company, by W. D. Cashin; Builders Iron Foundry, by F. N. Connet and C. J. Young; Chapman Valve Manufacturing Company, by J. T. Mulgrem; *Engineering Record*, by I. S. Holbrook; Darling Pump Manufacturing Company, by H. H. Davis; Goulds Manufacturing Company, by R. E. Hall; Hersey Manufacturing Company, by A. S. Glover, J. A. Tilden, and W. A. Hersey; Lead Lined Iron Pipe Company, by T. E. Dwyer; Ludlow Valve Manufacturing Company, by H. F. Gould; National Meter Company, by C. H. Baldwin, J. G. Lufkin, and H. L. Weston; Neptune Meter Company, by H. H. Kinsey and R. D. Wertz; Norwood Engineering Company, by C. E. Childs; Pittsburg Meter Company, by B. A. Lester; Platt Iron Works Company, by F. H. Hayes; Rensselaer Valve Company, by C. L. Brown; A. P. Smith Manufacturing Company, by F. L. Northrop and D. F. O'Brien; Thomson Meter Company, by E. M. Shedd; Union Water Meter Company, by F. E. Hall; Water Works Equipment Company, by W. H. Van Winkle, Jr., and E. S. Scott; R. D. Wood & Co., by C. R. Wood and H. M. Simons; Henry R. Worthington, by Samuel Harrison. — 30.

GUESTS.

John N. Brooks, Torrington, Conn.; J. J. Prindiville, water commissioner, Framingham, Mass.; Frank S. Hamlin, water commissioner, Haverhill, Mass.; A. E. Barrett, water commissioner, Lowell, Mass.; Daniel H. Gorman, commissioner, East Greenwich, R. I.; Henry F. Wilkins, John P. Goodwin, water commissioners, Marblehead, Mass.; Arthur W. Beckford, Henry Newhall, Danvers, Mass.; C. L. Leary, engineer public works, Peabody, Mass.; John J. Nugent, commissioner, Beverly, Mass.; Harry Greenhalgh, president Water Board, Fall River, Mass.; A. Allen, water commissioner, Westfield, Mass.; Raymond C. Allen, Manchester, Mass.; W. H. McGinty, Frank S. Bailey, and Tenny Morse, Boston, Mass.; Prof. H. C. Ives, Worcester, Mass.; and E. F. Hughes, water commissioner, Watertown, Mass. — 19.

The Secretary read the records of the last meeting. On motion of Mr. M. F. Collins the records as read were adopted.

The Secretary presented applications for membership, duly recommended and endorsed, from Henry Newhall, Danvers, Mass., superintendent; J. J. Prindiville, South Framingham, Mass., member and secretary Framingham Water Commissioners; Charles A. Leary, Peabody, Mass., in charge of Water, Street, and Sewer Division, Public Works; Charles William Saxe, Newport, R. I., chemist in charge of Filtration Plant, Newport Water Works; Earl W. Kelly, Duluth, Minn., engineer for Duluth Water and Light Department; Myron L. Fuller, Brockton, Mass., formerly chief of Eastern Section, Division of Hydrology, U. S. Geological Survey, and now consulting engineer on underground water supplies; L. E. Thayer, Waterville, Me., trustee Kennebec Water District and city treasurer; Samuel R. Hatch, Duluth, Minn., assistant to manager, Water and Light Department, Duluth; Marvin C. Birnie, Springfield, Mass., who has been engaged with the Thompsonville Water Company, Spafford Springs Aqueduct Company, and Stanton Aqueduct Company; Howard C. Ives, Worcester, Mass., assistant professor of railroad engineering, Worcester Polytechnic Institute. — 10.

On motion of Mr. T. A. Peirce, the Secretary was directed to cast one ballot in favor of the admission of the applicants, and he having done so they were declared duly elected members of the Association.

THE PRESIDENT. The members of the New England Water Works Association, I take it, are always glad to welcome anybody who is entering their business. We have such a man with us to-day, the Commissioner of Water and Fire Protection, Lowell, Mass., and it gives me pleasure to introduce Mr. A. E. Barrett, who will speak to you.

Mr. Barrett then spoke briefly in regard to the duties of his position.

The first paper of the afternoon was by Frederick N. Connett, mechanical engineer, Providence, R. I., on "Some Recent Applications of the Venturi Meter." The paper was illustrated by stereopticon views. The discussion of the paper was opened by Mr. Allen W. Cuddeback, who read a letter from Mr. John H. Cook, hydraulic engineer of the East Jersey Water Company. Mr. Richard A. Hale spoke of the successful work of the Venturi meter at Lawrence, and Mr. Connett replied to questions asked by Prof. Dwight Porter and Mr. Frank L. Fuller.

Mr. Richard K. Hale. Mr. President, it has come to my attention that several people have commented upon certain features of our Standard Specifications for Cast-Iron Pipe, and suggested revision. It has been suggested, therefore, that the matter be referred to the Committee on Cast-Iron Pipe, to determine whether these specifications should be revised or not. I therefore make the following motion: That the question of the desirability of revising the Standard Specifications for Cast-Iron Pipe be referred to the Committee on Pipe Specifications, with the request that they report on this matter at the next meeting of the Association.

The President. You have heard Mr. Hale's motion; is there anything to be said?

Mr. Dexter Brackett. As a member of that committee, I would like to ask if it is contemplated to refer the matter back to the original committee. I supposed that that committee had long ago gone out of existence.

Mr. Hale. I am informed that this committee is still in existence and that you are the chairman, and that Mr. McInnes and Mr. Forbes are the other two members.

Mr. Brackett. I wish to state that while I think it is desirable that the question of the Standard Specifications be considered, with a view of possibly adopting some changes which the experience of the last ten years has shown advisable, I should not be willing to retain the chairmanship of that committee, and really I should prefer not to be a member of it. I am, however, willing to give the benefit of any experience I may have had in the previous study of the question. I should think it would be well to have a committee of five, as I know there is much work to be done, and that the committee be appointed by the President. As to that committee making any report at the next meeting if that would mean anything in the shape of suggesting changes, I think there would be hardly time for that. I only offer this as a suggestion.

THE PRESIDENT. Mr. Brackett, the idea is simply that the committee will report on the advisability of making changes, — not to suggest the changes, but, if they deem it advisable and proper to have changes made, to report back to the Association at the next meeting so that we may act upon the matter then, and decide whether to appoint a new committee or to continue the old committee.

MR. BRACKETT. If that is the idea, I am satisfied.

(Mr. Hale's motion was adopted.)

THE PRESIDENT. The Executive Committee have been looking about for a place to hold the next annual convention. We sent out notices to the members, as you know, asking them to express their preferences. We have had 171 replies, and a summary of those replies is as follows:

First choice: Washington, 72; New York, 62; Philadelphia, 36. Scattering, 1.

Second choice: Washington, 26; Philadelphia, 71; New York, 37. Scattering, 2.

The committee have not yet decided upon the place, but they will probably be somewhat guided by the replies received from the members.

Mr. William S. Johnson, sanitary and hydraulic engineer, Boston, Mass., read a paper entitled "Some Things Domestic Meters do Not Accomplish." This paper was also illustrated by the stereopticon. It was discussed by Mr. Dexter Brackett, Mr. Allen W. Cuddeback, Mr. Frank L. Fuller, and Mr. George A. Carpenter.

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Wednesday, December 13, 1911.

Present: President Allen Hazen, and members Morris Knowles, Lewis M. Bancroft, Richard K. Hale, Robert J. Thomas, and Willard Kent.

Five applications for membership were received and recommended for admission, namely:

For membership: John L. Hyde, city engineer, Westfield, Mass.; Walter E. Miller, C. E., Railroad Commission of Wisconsin, Madison, Wis.; Charles H. Ross, superintendent Waterloo Water Company, Waterloo, N. Y.; Alfred A. Young, superintendent Jewett City Water Company, Jewett City, Conn.

For associate: Eddy Valve Company, manufacturers of valves and hydrants, Waterford, N. Y.

Adjourned.

Willard Kent, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, January 10, 1912, at 11.30 A.M.

Present: President Allen Hazen, and members J. Waldo Smith, Michael F. Collins, Leonard Metcalf, Irving S. Wood, Frank A. McInnes, Morris Knowles, Lewis M. Bancroft, Richard K. Hale, and Willard Kent.

Six applications for membership were received and recommended for admission, namely:

Sam H. Pitcher, assistant engineer, Worcester, Mass.; Hervey A. Hanscom, contracting engineer, Boston, Mass.; Lewis L. Wadsworth, president Hanscom Construction Company, Boston, Mass.; Herbert F. Salmonde, chemist West Parish Filters, Springfield Water Works, Westfield, Mass.; Paul Hansen, engineer Illinois State Water Survey, University of Illinois, Urbana, Ill.; Harrington P. Stearns, assistant engineer Queens County Water Company, Far Rockaway, N. Y.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, at 2.30 P.M., Friday, January 26, 1912, pursuant to call of President.

Present: President George W. Batchelder, and members Frank A. McInnes, Randolph Bainbridge, Lewis M. Bancroft, Richard K. Hale, George A. King, and Willard Kent.

Voted: On motion of Mr. King, seconded by Mr. Bancroft, that the Secretary be instructed to send with the notices of the February meeting a request for the members to express their preference of a place for holding the next annual convention.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at the rooms of the Association, Tremont Temple, Boston, Mass., February 14, 1912, at 11.30 A.M.

Present: President George W. Batchelder, and members Frank A. McInnes, George A. Stacy, Richard K. Hale, George A. King, and Willard Kent.

The Treasurer's bond for $5 000, by the Massachusetts Bonding and Insurance Company, was presented and by unanimous vote approved.

Ten applications for membership were received and recommended for admission, namely:

For members: Henry Newhall, superintendent water works, Danvers, Mass.; J. J. Prindiville, water commissioner, Framingham Mass.; Charles A. Leary, engineer, Commission of Public Works, Peabody, Mass.; Charles W. Saxe, chemist in charge Filtration Plant, Newport, R. I.; Earl W. Kelly, engineer Water and Light Department, Duluth, Minn.; Myron L. Fuller, consulting engineer, Boston, Mass.; L. E. Thayer, trustee Kennebec Water District, Waterville, Me.; Samuel R. Hatch, assistant to manager, Water and Light Department, Duluth, Minn.; Marvin C. Birnie, civil engineer, Springfield, Mass.; Howard C. Ives, professor water supply and railroad engineering, Worcester Polytechnic Institute, Worcester, Mass.

The result of ballot by members on place of holding next annual convention was presented as follows:

Replies were received from 171 members.

	First Choice.	Second Choice.
Washington	72	26
Philadelphia	36	71
New York	62	37
Boston	1	1
Providence	..	1

After a discussion, the matter was referred to a later meeting of the Executive Committee.

Adjourned.

WILLARD KENT, *Secretary.*

New England Water Works Association.
ORGANIZED 1882.

Vol. XXVI. June, 1912. No. 2.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

HOW THE WATER EMERGENCY AT WORCESTER, MASS., WAS HANDLED IN THE SUMMER OF 1911, TOGETHER WITH A BRIEF DESCRIPTION OF WORCESTER'S SOURCES OF WATER SUPPLY.

BY FRANK C. KIMBALL.

[*Read March 13, 1912.*]

In the summer of 1911 the city of Worcester, Mass., experienced a water shortage, not to call it a famine. Several possible sources of supply to relieve the stringency were considered, and, while some of them were later used to some extent, it was soon recognized that about the only source which combined both quantity and quality was the Wachusett reservoir of the Metropolitan Water Works, in the towns of Boylston and West Boylston. The nearest available point at which this source could be tapped was about eight miles from the City Hall in Worcester, and at an elevation at high water of about 92 ft. below the street at the City Hall, about 330 ft. below the low-service reservoir supply and about 435 ft. below the level of the high-service reservoirs of Worcester. It, therefore, was a serious question — at a time when the water stringency had become so great that further delay could not be tolerated, — whether the necessary pipes, machinery, etc., could be obtained and installed in season to be of benefit to the city. In fact, at a conference between the State Board of Health and officials of the city of Worcester in Boston, on July 20, the opinion was expressed by the chairman of that board, that it would be a physical impossibility to get the Metropolitan water into the city in time to be of use.

It was fortunate for the city that it had as its mayor at this time, the Hon. James Logan, a thoroughly trained business man, versed in handling large business enterprises and, therefore, capable of dealing with the important questions involved in an undertaking of this character. Believing that the materials could be found and the work done, all without unnecessary delay if the problem were attacked in the right way, he lost no time in getting in touch with various parties whom he thought might help the city in its crisis. Among others whom he consulted in the matter was the Stone & Webster Engineering Corporation of Boston, who, while not to any material extent operating along water-works lines, suggested certain ways and methods by which it was thought the project could be carried out. Examinations were made by them in behalf of the city, together with some inquiries as to the possibility of obtaining the necessary supplies to prosecute the work.

On Friday noon of August 4, the writer was asked by Mr. F. N. Bushnell, engineering manager of that corporation, to go to Worcester, examine certain proposed routes for a pipe line from Wachusett reservoir to the city, determine the sizes of pipe necessary to deliver over the routes examined not less than 6 000 000 gal. of water daily into its low-service system, and to report in full by the following Tuesday at noon. He spent that afternoon and the following day going over the ground as well as following up the situation in the offices of the city engineer and of the water commissioner, including also several conferences with the mayor and the city attorney, and on Tuesday noon submitted his report to Mr. Bushnell, followed the next day with an estimate in detail of the cost of so much of the work as had been embraced in his studies. This report recommended the route finally adopted but with the further recommendation that certain reinforcing mains be laid by and in the city to supplement those already in place between that section known as " Summit,"— where it was proposed to connect with the city's mains, — and Lincoln Square, where it was required to deliver the water to a 30-in. low-service pipe. Attention was also directed to the fact that even with these changes it might be difficult to give proper service to certain portions of the city on Burncoat Hill and in the Greendale section if the high-service mains then supplying these sections were diverted from their uses and used to bring in the water for the low-service supply.

Owing to the illness of the city engineer, Mr. Frederick A. McClure, Mayor Logan on Wednesday, August 9, appointed Mr. Charles A. Allen, M. Am. Soc. C. E., formerly city engineer of Worcester and member of long standing in this association, as consulting engineer upon the entire question of emergency supplies of water, he to assume control of all construction required by whatever plans were adopted, and particularly to see that the work was prosecuted to a speedy conclusion. Acting at once in the matter, on the following day he in company with the mayor had a conference at the office of Stone & Webster with members of that organization, at which the writer was present, where all information gathered by that concern was placed at the full disposal of the city and the tender of such assistance as they could render them, made. As one of the results of this conference, on the following Saturday, August 12, the writer was engaged by Mr. Allen to assist him in carrying out the work for which he had been retained, and he immediately went to Worcester for that purpose.

As there was at this time less than 80 000 000 gal. in the low-service reservoirs, and the almost certain necessity was seen of having to use the water in the high service to supplement the low before the Metropolitan supply could be completed, it was early decided by Mr. Allen that any supply brought to the city would have to be under a pressure sufficient to supply the high service as well as the low and of such capacity that, if weather conditions did not help the city, it would be ample for practically the entire daily consumption. Further, as, by so doing, the complications due to attempting to use certain of the high-service mains under low-service conditions would be obviated, the plans finally adopted were upon the basis of pumping 10 000 000 gal. a day into the high service.

It was further decided to take the water, subject to the permission of the Metropolitan Water and Sewerage Board, from a point in Wachusett reservoir in South Bay, near the entrance of Muddy Brook, so called, and where at high water there was a depth of upwards of 40 ft., and to bring the supply into Worcester by way of Hartwell and Burncoat streets, delivering it to the city's high-service mains at West Boylston and Mountain streets in that section of the city known as "Summit." To reduce the friction head as much as possible, a 30-in. pipe line was found to be desirable. Estimates of cost covering the work upon this plan were made and submitted to the mayor on the morning of August 14, and by him transmitted to the City Council that same evening, at which time by resolution, the consulting engineer, Mr. Allen, under the direction of the mayor, was ordered to proceed with the work and do all things necessary to procure and make available at the earliest possible moment an emergency water supply delivered into the high-service mains as above outlined. The estimated cost of this work, $153 000, was, with other amounts, appropriated at this same meeting.

The necessity of changing the plan so as to permit of taking care of the high as well as of the low service, and of providing sufficient capacity to substantially meet the full daily needs of the city, as well as the need of haste in the execution of the work, may be seen from the fact that on August 5, with a daily average consumption in the month of July of about 10 700 000 gal., of which about 4 850 000 gal. came from the high-service sources, and about 5 850 000 gal. from the low service, there was in storage, in the Tatnuck or low-service reservoirs, only about 80 000 000 gal., and in the Kettle Brook and Lynde Brook reservoirs, supplying the high service, about 580 000 000 gal. Thus the low service had only about fourteen days' supply on that date for its portion of the city, after which, if not replenished, the high-service supplies would have to be called upon to supply the entire city. Upon the assumption, fair at this season of the year, — August and September, — that any yield from the watersheds would probably be sufficient only to care for evaporation at the best, the entire supply in storage on August 5, about 660 000 000 gal., after deducting such of it as was not available, would supply the city for from sixty to sixty-five days.

In order that a clear understanding of the situation at this time may be had, a brief description of the various sources supplying Worcester will be of interest.

At this time, all of its water supply is obtained by gravity from three brooks, all tributary to the Blackstone River. These had been developed by the construction of dams across these streams at advantageous points, thus forming seven storage reservoirs. The accompanying map (Plate II) has been prepared through the courtesy of the city engineer's office in Worcester, and outlines these various supplies, indicating as well certain contemplated additional sources from which Worcester expects to draw, as well as showing the various emergency sources utilized in the summer and fall of 1911.

The original source of Worcester's water supply was Bell Pond on Belmont Hill, which in turn was fed by an aqueduct from Putnam's Meadow, so called, to the northeast of this pond. This was the sole supply of the city until the early '70's when the Lynde Brook supply was developed. After Lynde Brook supply was turned on to the city, Bell Pond was used more or less, and particularly as an emergency supply, until about 1898, when it was finally abandoned.

The oldest supply of those now in use is that of Lynde Brook. This has a drainage area of about 2.92 sq. miles and a storage of 700 581 000 gal. From this reservoir is taken all the high-service supply for the city, through the main gatehouse near the lower end of the reservoir. Some distance up the easterly side of this reservoir is another gatehouse controlling the flow through a 30-in. conduit to Parson's reservoir, a distributing reservoir at the same elevation as the low-service reservoir No. 2 of the Tatnuck system. Through this connection the waters of Lynde reservoir may be used for the low service also, the prevailing practice being to take a limited portion of the low-service supply from this source as well as all of the high service. There are likewise several gated cross-overs about the city by means of which the high service can be connected with the low service.

To the west of the Lynde Brook watershed is that of Kettle Brook. This watershed has an area of about 3.62 sq. miles, the storage of which has been developed by four reservoirs with a combined capacity of 812 362 000 gal. The lower one of these, Kettle Brook No. 1, is connected to the Lynde Brook reservoir by a 30-in. conduit, through which all utilized waters of the Kettle Brook watershed flow.

Draining into Kettle Brook Reservoir No. 1 from the west, but without any independent storage, is Peter Brook, having a drainage area of 0.48 sq. miles. This brook formerly drained into Kettle Brook some distance below the reservoir but is now diverted so as to feed into Worcester's supply. These three brooks combined give a total drainage area of 7.02 sq. miles, with a storage of about 1 512 943 000 gal., all available for Worcester's high-service system and also capable as above described for the low service when needed, being to some extent usually so used.

To the northeast of the Lynde Brook watershed is that of Tatnuck Brook, sometimes called the Holden supply from the town in which it is principally situated. This is used solely for the low service of Worcester, and has a watershed area of about 5.23 sq. miles, with a developed storage by means of two reservoirs of about 986 717 000 gal. without the use of flashboards. Eighteen-inch-high flashboards are sometimes used in the overflow of these two reservoirs only, and when so used, increase their capacity by about 91 190 000 gal. Together, these two systems have a combined watershed of about 12.25 sq. miles with a developed storage when flashboards are used of about 2 590 850 000 gal. and at this time constituted the entire water supply of Worcester.

An examination of a topographical map of this region will show that Worcester is situated in a comparatively high altitude and very close to the divide separating the various watersheds of Eastern Massachusetts. It has, therefore, a somewhat limited area from which to draft a water supply without pumping against high heads. About eight miles northwesterly from the city, in the town of Paxton, is the summit or apex of four different watersheds, where head: Turkey Hill Brook, draining generally in a southwesterly direction into the Chicopee River; Town Meadow Brook, draining southerly into the Quinebaug River; Tatnuck, Lynde and Kettle brooks, draining southeasterly into the Blackstone River; Asnebumskit and Kendall brooks,

draining northerly and easterly into the Quinepoxit River and forming part of the watershed of the south branch of the Nashua River, which in turn, by means of the dam just above Clinton, forms the Wachusett Reservoir, supplying the larger part of the Metropolitan water for Boston and vicinity.

Another watershed, that of Ware River, heads in the town of Rutland, just to the north of Paxton and to the west of the Nashua River watershed.

These are all shown on Plate II and indicate better than can any description the extent to which Worcester had to this date developed all water supplies within what may be termed its territory.

Foreseeing, however, the ultimate necessity of going beyond the Blackstone River shed for an additional supply, Worcester had retained, in Chapter 488 of the Acts of 1895, the original act creating the Metropolitan Water District, the right to take water from the Nashua River watershed under certain conditions. This right was extended and amplified by subsequent legislation in 1897 and again in 1902 when, by Chapter 351 of the Acts of that year, authority was expressly granted to Worcester to take the waters of both Kendall and Asnebumskit brooks under the conditions contained in said Act. Proceeding under the terms of this legislation, while no legal taking of the water had then been made, more or less construction work leading to the development of these sources had been done at this time. Both Kendall and Pine Hill reservoirs as they formerly existed were storage reservoirs, built and maintained by the mills on the streams below, and before being disturbed by the city had estimated capacities of 82 000 000 and 119 000 000 gal. respectively. To this time in connection with the general plan for using these waters, Worcester has constructed a receiving pool, discharging into the head of Tatnuck Brook, a conduit, built partly in tunnel and partly in open cut, through the divide, to and through a gatehouse in a dike, also built at the southerly or upper end of Kendall Reservoir. This dike was required for the purpose of raising the water level higher than the natural divide between the two sheds and providing more storage than otherwise would have been available. The conduit through this dam continues about half way through Kendall Reservoir.

Above Kendall Reservoir and about half way between Pine Hill Reservoir and Eagleville Pond, a diversion dam and headworks have been built across Asnebumskit Brook, and an open conduit or canal, lined with concrete, constructed from these headworks to Kendall Reservoir, into which it discharges.

To digress at this point, it may be stated that the Asnebumskit and Kendall watersheds combined, which will thus be utilized, cover about 9.48 sq. miles, and will, when developed, with the existing watersheds, give Worcester a watershed area of 21.73 sq. miles to draw from. The present plans contemplate the building of a dam at the northerly end of Kendall basin, near the present outlet of Kendall Brook (this dam being at the present time, March, 1912, partially completed) and of a height to materially increase its former storage capacity, together with the extension of the conduit or channel through the reservoir so that it may entirely drain through the divide into Tatnuck Brook. Later and as a part of the same general scheme, it is intended to develop the Asnebumskit Brook watershed by the construction of a new dam near but a little above the site of the present one at Pine Hill and with a flow line at elevation about 902, taking the waters so stored through the channel of the brook to the headworks above outlined, thence through the open channel or canal, discharging into Kendall Reservoir and from there through the conduit into the head of the Tatnuck system. These improvements are expected to give Worcester an additional storage capacity in Kendall Reservoir of about 814 500 000 gal., and in Pine Hill Reservoir of about 2 155 000 000 gal. When completed, Worcester will thus have a total storage of 5 469 160 000 gal., without the use of flashboards, which with its then combined watershed of 21.73 sq. miles should be ample for a population of considerably over 250 000.

On July 1, 1911, the city had in its low-service or Tatnuck reservoirs, about 245 000 000 gal., of which about 225 000 000 gal. were available. On the same date in the Lynde and Kettle Brook reservoirs, the high-service system, were about 749 000 000 gal., 351 000 000 being in the Kettle Brook and 398 000 000 in Lynde Brook reservoirs. Of this quantity about 714 000 000 gal. could be drawn for use. On August 5, as above stated, the total quantity in storage was about 660 000 000 gal., thus showing a loss of 334-

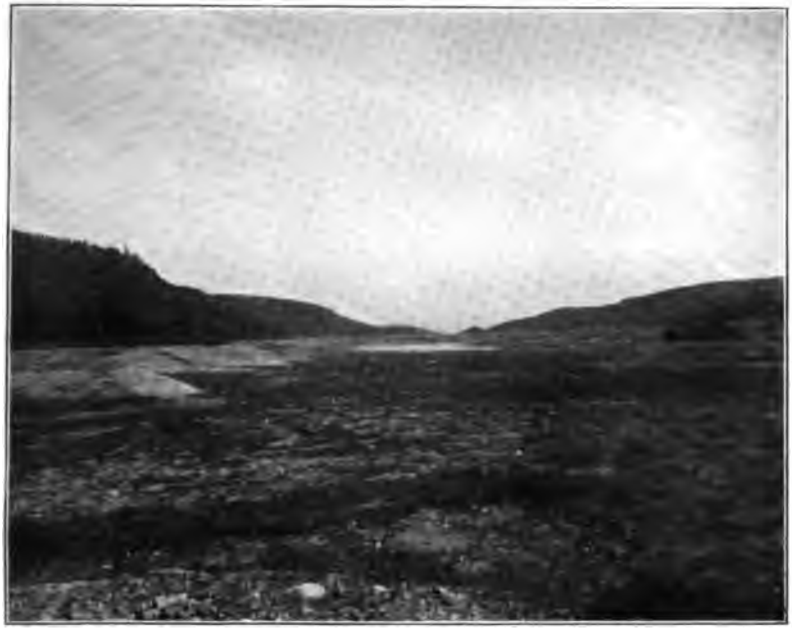


FIG. 1.
HOLDEN NO. 1, FROM UPPER END, SOUTHERLY, AUGUST 1, 1911.

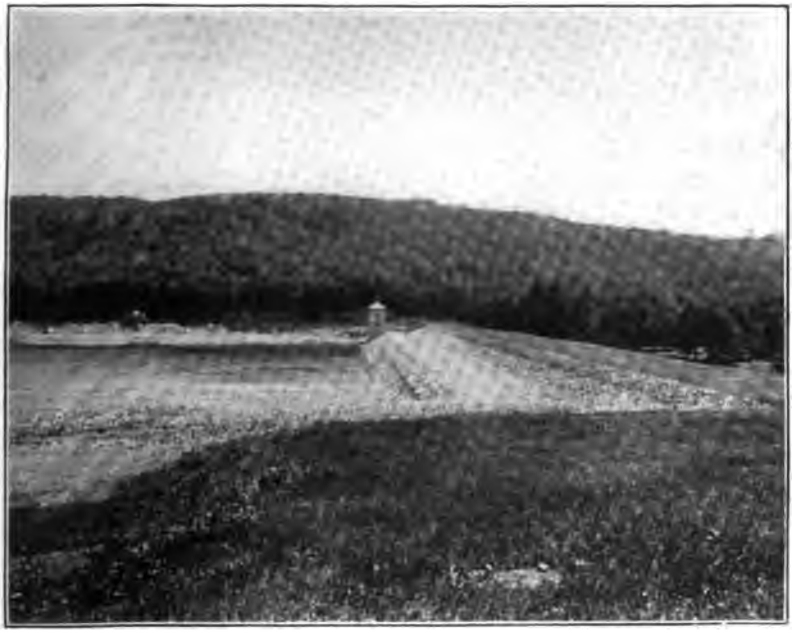


FIG. 2.
HOLDEN NO. 1. LOW WATER AT DAM, JUNE 8, 1911.
Views showing depletion of reservoirs.

M 70

000 000 gal. in thirty-six days, or an average of about 9 300 000 gal. per day.

During the month of June, the city had used, in round numbers, 333 000 000 gal., a daily average of 11 100 000 gal.

Thus facing a draft of between nine and ten million gallons per day in excess of yield, on July 1 it was apparent to anyone that Worcester might easily be out of water by October 1st to the 15th. To the mayor, the city engineer and the water commissioner it had been evident long before this time that unless relieved by rains, Worcester was facing a water famine. For several years prior to this date, both the city engineer and the water commissioner in their yearly reports had recommended that steps be taken to permanently augment the supply, and to this end not only had complete plans been prepared but work had been carried forward along the lines of such plans to the extent above outlined, — all that could be done with the means provided therefor. The work had not, however, at this time progressed to a point where it rendered available any addition in quantity to the supply although some considerable portion of the work then completed was of very great assistance in handling certain of the emergency supplies furnished the city later.

The first real official recognition of the existence of an emergency in the water supply by the City Council was made on June 26, when it instructed the water department to take all necessary steps to curtail the use of water, and particularly to see that all hose, street sprinkling, etc., was discontinued. This was done at once, a rigid inspection maintained, railroads were required to obtain their water at other places whenever possible, and such other steps taken as would insure the use of water for absolute domestic and business necessities only. Still the first week in July showed a drop in the storage of approximately 10 000 000 gal. daily. All waters in the upper reservoirs were drawn into the lower ones to reduce evaporation as much as possible. As a preliminary step looking to its use as a possible supply, although at that time having no legal right to the water, the mayor entered into an agreement with the owners of Pine Hill Reservoir not to draw down the water then in storage for the mills below but to leave it for the possible use of the city.

On July 10 the City Council authorized the city engineer and the water commissioner, acting under the direction of the mayor, to take the waters of Asnebumskit Brook, Lake Quinsigamond, and such other available source or sources as in their judgment the exigencies of the city demanded, procuring and erecting all necessary pumping and other machinery, pipes and appurtenances, etc., an appropriation being made for that purpose.

The city of Worcester for over thirty years has kept installed on the shore of Coes Pond, a pumping plant for use in any emergency that might arise, and in that period, although not for a number of years prior to this time, it had been so used. An order had been passed by the City Council as long before as December 28, 1910, to prepare the pumps at Coes Pond for use in case of necessity, and to erect such additional boilers and pumps as might seem desirable, which was done. Coes Pond and Reservoir combined were estimated to hold about 250 000 000 gal. of available water, and it was all along thought it could be used to help Worcester out of its troubles. On January 5, 1911, the State Board of Health approved the use of these waters in the event of a drought, although as a matter of precaution recommended that the inhabitants be cautioned to boil the water before drinking. This permission was reiterated by the board on March 28, and the officials of the city had been relying largely upon this source to relieve any stringency that might arise. However, so much public sentiment had been created against the use of this water that on July 20, at the conference before mentioned, the State Board of Health decided that this water could not be used except as a last resort, and as a consequence a complete change in plan was necessary.

Lake Quinsigamond waters could not be used directly from the lake on account of pollution due to the state hospital on the hill to the west, and also that due to the cottages and places of amusement surrounding the lake. Consideration, however, was given to driving wells near the shore, thus obtaining benefit of ground infiltration as well as of such water as might otherwise be obtained from the wells. The question of the installation of filter beds and other means of purification were likewise considered, but the time required for these latter schemes appeared to make them im-

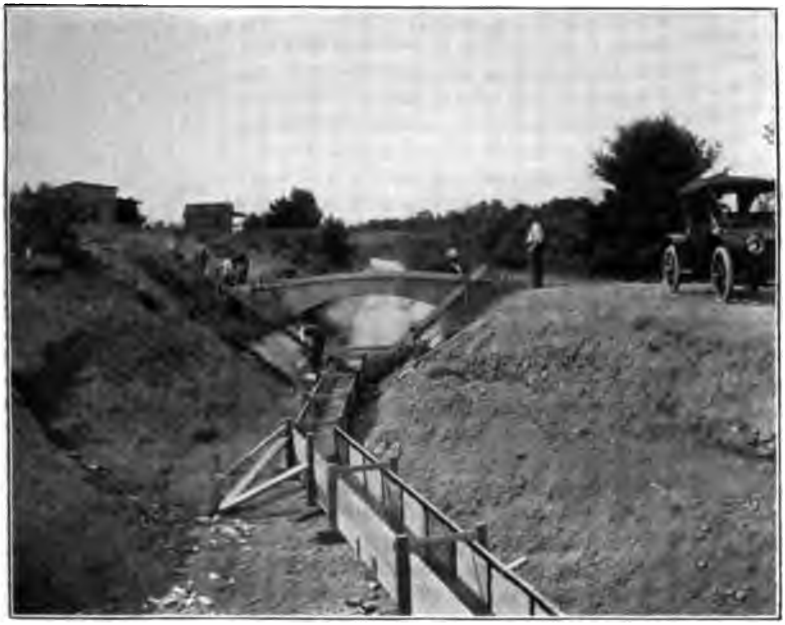


FIG. 1.

UPPER END OF SLUICE AT END OF DODD ROAD, LOOKING NORTHERLY UP CANAL. AUGUST 1, 1911.

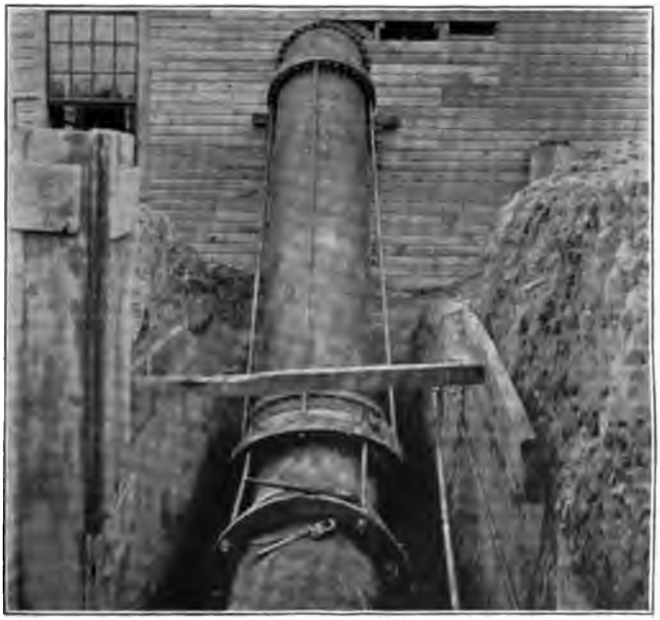


FIG. 2.

30-INCH DISCHARGE PIPE FROM PUMPING STATION ON WACHUSETT RESERVOIR, SHOWING TIE-RODS IN PLACE.

practicable, and as, in the experimental wells sunk, much rock, bowlders, etc., were encountered, it was finally decided to abandon further consideration of this source.

The waters in Pine Hill Reservoir being unhesitatingly approved by the State Board of Health, steps were taken at once to complete the channel in the upper end of Kendall Basin so as to permit of the flow of these waters to Tatnuck Brook. As the water could not be turned directly into Kendall Basin from the canal without flooding the construction work then in progress along the lines of the permanent plans, and as it also could not be held in the basin, with the old outlet dam removed and the new one not built, without considerable cofferdam work, it was decided by the city engineer, with the approval of the mayor, to build a wooden flume or sluiceway, following somewhat the contour of the basin, from the southerly end of the canal from Asnebumskit Brook to a point where the conduit from Tatnuck could receive the water and keep it confined within its banks, a distance of about 4 700 ft. Accordingly a contract was negotiated by the mayor on July 20, immediately after returning from the conference with the State Board of Health in Boston, for building the same. The sluiceway as designed had a safe carrying capacity of upwards of 8 000-000 gal. per day. This work was finished August 1, and on that day water from Pine Hill Reservoir was first let into Worcester's water system.

An examination of the ground and a report thereon by Prof. W. O. Crosby, geologist of the Massachusetts Institute of Technology, encouraged the city in the belief that water could be obtained from the basin of Kendall Reservoir by means of wells, and some sixty shallow wells of 2½ in. pipe were driven in the bottom of this basin. These wells ranged from 24 to 32 ft. in depth, penetrating a coarse sand in nearly all instances. Two gasolene pumping engines were obtained, the wells connected up to these, and the water so obtained pumped into the same sluice which carried the waters from Pine Hill Reservoir. Pumping from these wells continued until about the first of October, when, a vacuum of from 22 to 24 in. being required to raise the water, pumping ceased and this source was abandoned.

When Mr. Allen assumed charge of the emergency work the sluiceway had been built and the city committed to the driving of the wells in Kendall Basin. Believing as he did that with all the water then in sight, including the 119 000 000 gal. in Pine Hill Reservoir, such reserve as could be obtained from Asnebumskit Brook and Pond above Pine Hill and with what could be pumped from these wells, it all was likely to be exhausted before the Metropolitan supply could be made available, he further recommended to the mayor and through him to the City Council at its meeting on August 14, that authority to take the waters of Eagleville Pond be given, — this having an available estimated quantity in storage of about 240 000 000 gal.,—that pumping machinery be erected and a pipe line laid from this pond to the lower end of the canal on Dodd's Road, so called, where the wooden sluiceway joins this canal, to enable this pond water to be pumped into the flume. An appropriation of $21 000 was asked for this purpose, which was voted and the authorization to take the waters granted.

Thus, on August 14, only five days after his appointment, appropriations had been made, based upon plans and estimates worked out in that time by Mr. Allen with the writer's assistance, and the work ordered forward. It may at this time be pertinent to say that the Metropolitan job, so called, which of course was the important one, estimated to cost $153 000, actually did cost $153 626.29, as shown by the city auditor in his annual report to the City Council at the close of 1911, being within about four tenths of one per cent. of the estimate. This is mentioned only to emphasize the fact that although the time was extremely limited, the work was carefully planned, estimated, and then constructed in fairly good accord with such plans. It is further pertinent to state that while the general scheme was well in hand and inquiries had been made as to where and how soon some of the machinery, pipes, etc., could be obtained, none had been purchased nor contracts let at the time the appropriations were made and the final order given by the City Council to proceed with the work.

The Eagleville Pond supply was placed under the immediate charge of Mr. Samuel H. Pitcher, M. Am. Soc. C. E., formerly of the city engineer's office of Worcester, and a member of this Association. Three pumps, obtained from stock on hand of the

Deane Steam Pump Company, of Holyoke, Mass., were erected in an old power house of the Worcester Consolidated Street Railway Company, which was advantageously situated upon the shore of this pond. The Railway Company also had a couple of boilers at their Millbury power house, not then in use, which were of suitable size for this work, which they loaned to the city. These were erected in this power house, and thus at comparatively small expense a temporary pumping plant was installed. The pumping head including friction with all three pumps running was about 120 ft., the capacity being about 4 500 000 gal. per day.

A 12-in. force main was laid, about 4 900 ft. long, from this power house to the sluiceway as above described, about a third of the way being across private property and the remainder of the distance in Dodd's Road, so called. The larger part of this pipe was from the stock of the Worcester Water Department, supplemented by some found on hand at one of the foundries from which quick delivery was had. Several contractors were asked to submit bids for laying this pipe, two being received; but as the lowest of these was for $1.50 per ft., both were rejected and the Water Department laid it with their own force and at a cost of a fraction under fifty cents per foot. The entire work was completed and pumping began on September 27, twenty days after actual work was started on this job. The total cost of the Eagleville Pond supply, as given by the city auditor in his annual report, was $18 044.22, — $2 955.78 under the estimate.

From the moment of the passage of the necessary orders by the City Council on August 14, work proceeded as rapidly as possible upon the principal emergency job, known as the Metropolitan supply. While the matter had been discussed with them before the first of August by the mayor, and it was tacitly understood that permission would be granted by the Massachusetts Water and Sewerage Board to take water from Wachusett Reservoir, formal permission was not granted until August 28. Work, however, was not delayed on this account.

Within about 1 500 ft. of the selected location for the pumping station upon the shore of Wachusett Reservoir, and crossing the proposed pipe line were the high-tension lines of the Connecticut River Transmission Company, carrying electric current under

65 000 volts pressure. This was one of the controlling factors determining the use of electrical machinery to operate the power station, — other considerations being the lesser cost of first installation as compared with steam pumping engines, boilers, etc., smaller and consequently less expensive buildings and foundations, quicker delivery of machinery and more cleanliness in operation, — this latter factor being important particularly to the Metropolitan Water Board, owing to the location of the plant. Cost of operation by electrical power was not analyzed for this particular job, but was considered to be at least as cheap as steam power, owing to the distance coal would have to be hauled and the lesser amount of labor required to operate an electrically driven station than would be the case with a steam plant of the required capacity, which was about 1 500 horse power when pumping at a ten-million-gallon rate against a pumping head of 550 ft., these being the conditions to be met.

On August 15, the day following the authorization of the work, a contract was closed with the Alberger Pump Company of New York for 3 two-million-gallon, 4-stage turbine pumps, guaranteed to operate at this capacity against the full head of 550 ft. Shipment was promised of the first unit September 5, the second on September 9, and the third September 12, — all with a forfeiture and bonus clause. The average date of actual shipment was the exact contract date. The Alberger Pump Company also gave the city options on two additional pumps of the same type and at the same price, with a delivery of four weeks after receipt of order. Taking some chances on weather conditions, it was decided not to order these additional pumps until later, but this was the only departure from the full 10 000 000 gal. capacity required, in the machinery, pipes, etc.

On August 15 contract was entered into with the Connecticut River Transmission Company for power to the maximum demand of 800 k.w. with options under certain conditions to increase it to 1 300 k.w., this to be delivered at the pumping station in the form of 3-phase, 60-cycle, 13 200-volts alternating current. As the actual quantity of current desired was largely dependent upon weather conditions, no minimum rate or consumption was guaranteed, but in lieu of a minimum, the city agreed to pay for certain

PLATE V.
N. E. W. W. ASSOCIATION.
VOL. XXVI.
KIMBALL ON
WATER SUPPLY AT WORCESTER.

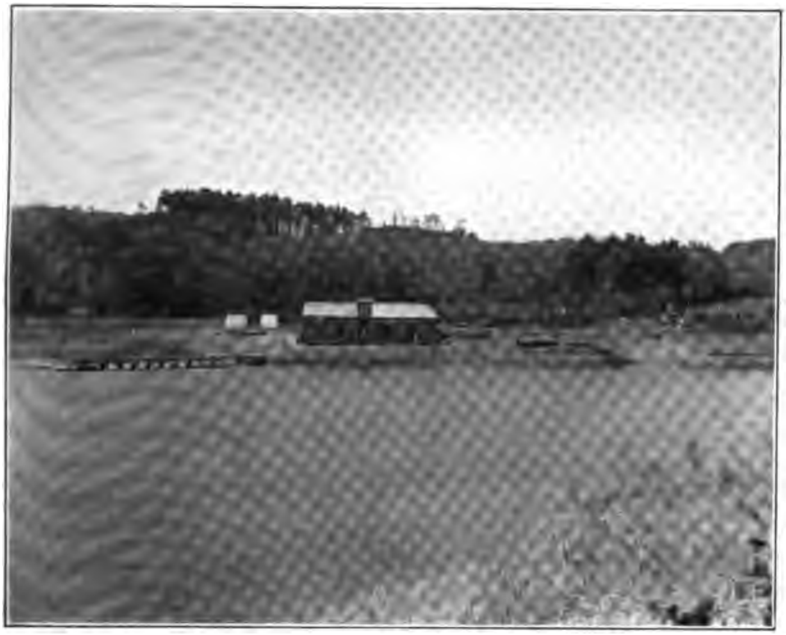


FIG. 1.
VIEW OF PUMPING STATION.

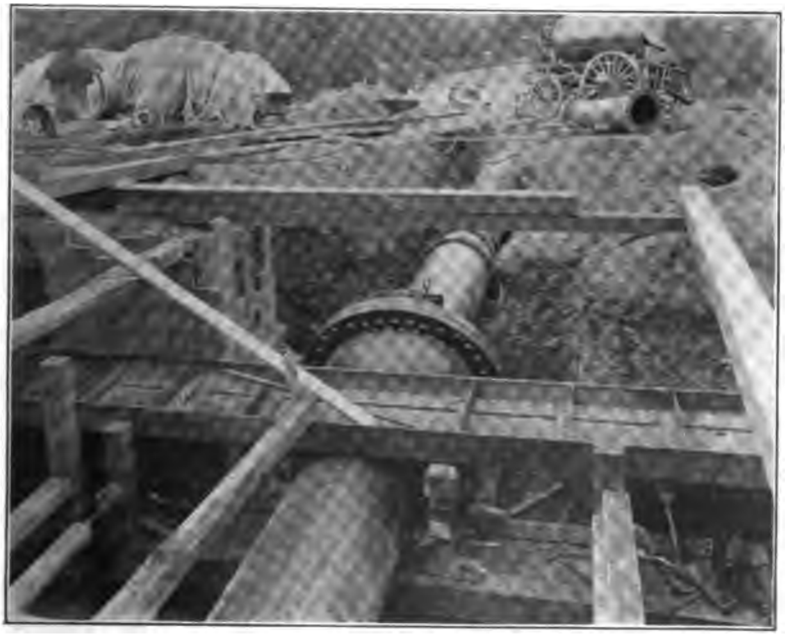


FIG. 2.
30-INCH CHECK-VALVE.

additional construction required to be done by the Connecticut River Company to carry out this contract, such to remain its property. The city also paid all costs of bringing the power from the company's lines to the pumping station.

On August 23 a contract was entered into with the General Electric Company to furnish the electrical outfit, consisting of 5 250-h.p. motors, with starting devices complete; 3 210-k.w. air-blast transformers; 2 blowers; 9 100-k.w. oil-cooled transformers; 1 lightning arrester equipment; 1 feeder and 5 motor switchboard panels. This material was to be shipped at varying intervals ranging from ten days to four weeks, except in the case of 1 blower requiring six weeks, 1 motor eight weeks, and the 9 100-k.w. transformers, ten weeks for delivery. All of this material was shipped and received as contracted for. To provide for transformers, — the only part of this apparatus that might cause delay, — an arrangement was entered into by the Connecticut River Transmission Company with Crocker, Burbank & Co., of Fitchburg, Mass., for the use by the city, for two months, of three large transformers they had, suitable for this work, thus tiding the city over the delay incident to receiving its own.

On August 24 a contract was signed with the Stone & Webster Engineering Corporation, to erect and install the pumping machinery complete, including the building, suction pipes, intake chamber and screens, and all discharge connections to the outside of the building. This covered also the preparation of the plans of the electrical installation and the inspection, etc., of the machinery furnished, all subject to Mr. Allen's general supervision. Under this contract ground was broken on September 12 at the pumping station, and on October 22, forty days thereafter, water was being pumped with everything in complete working order.

Coming now to the pipe line, on August 16, a contract was entered into with F. A. Houdlette & Son, Inc., of Boston, to furnish all cast-iron pipe and special castings required, including all flanged work at the pumping station. This contract called for 12 600 ft. of 30-in. pipe of classes D, F, and H of the New England Water Works Association Standard Specifications; 480 ft. of 24-in. Class D pipe; and 1 500 ft. of 12-in. pipe of Classes C and H. Shipment was to commence August 19, and to average 1 200 ft. per day until the entire quantity was shipped. It should be borne in mind that all this pipe had yet to be cast except about 173 lengths already on hand, which the city agreed to accept. The specials and flanged work were to be shipped within three and four weeks after receipt of specifications. The first shipment of pipe was made on August 17, one day after signing the contract, and the last shipment (except two cars shipped September 14) on September 8. The first car to arrive at Worcester was on August 31, and the last car September 27. Some few special castings came later but did not materially delay the work.

On August 18, contract was closed with the Builders Iron Foundry, of Providence, R. I., for a 30-in. Venturi meter, with 10-in. throat, together with a combined register-indicator-recorder, all to be delivered within four weeks. This meter was necessitated by the agreement with the Metropolitan Water and Sewerage Board, which required payment for all water taken by the million gallons. This meter arrived in Worcester two days ahead of schedule time. When setting the Venturi tube, it was discovered that the two sections on the outlet end were defective. This discovery was made just as they were about to be placed in the pipe line one Wednesday afternoon, at about three o'clock. By the use of the telephone, supplemented by a trip of the writer to Providence that night and a personal conference with the officials of the foundry, these two specially designed castings, for which patterns had to be made, were put through and delivered to a motor truck on the following Saturday evening and delivered on the work on Sunday morning, being set in place that same day.

This was only one of the numerous uses made of auto trucks as well as of automobiles in the prosecution of this work. The automobile used by the engineers had a record of over 3 600 miles in a little under ten weeks' use, frequently being employed from twelve to fifteen hours of the day. Its use undoubtedly more than doubled their radius of action, and to-day this means of locomotion is well-nigh indispensable under modern construction methods.

On August 21, a contract was closed with the Chapman Valve Company for 3 30-in., 1 24-in., 3 12-in. flanged, and 5 6-in. blow-off gates, all to be delivered within three weeks, which contract likewise was fulfilled on time.

On August 19 a contract was made with the Ludlow Valve Company for 1 30-in. swing-flap check valve; 3 12-in. extra heavy check valves for working pressure of 240 lb., and 3 12-in. foot valves for the suction pipes, also to be delivered within three weeks. On August 22 a contract was closed with the same company for 1 30-in. check valve, to be built for a working pressure of 230 lb., to be delivered in as much under six weeks as possible. In connection with this check valve, which weighed 13 900 lb., was another of the quick movements of the job. All of the pipe and most of the other carloads of freight had come over the Boston & Maine Railroad, and several times delays had occurred which had caused the question of deliveries to be taken up direct with the superintendent of that division of the railroad. About a week before this check valve was ready to ship, acting upon information from the factory, we notified the superintendent that it would be delivered to his road at Troy, N. Y., on Saturday afternoon, September 30, and that it was wanted as quickly as he could get it to us. It was loaded at Troy that Saturday at about 3 P.M. and at six o'clock on Sunday morning it was in the Worcester freight yard. While this was the quickest freight delivery on this job, — possibly it is safe to say on any other as well. — still it was only one of many acts which contributed to hurry forward the work, not alone on the part of the railroads but of all others connected with the job.

On August 15, specifications having been prepared, proposals were invited for teaming and laying the pipe and appurtenances. While these were not advertised owing to lack of time, six parties thought to be equipped to handle this work were asked to bid. From these four bids were received and opened on August 18. These ranged in amount from that of E. D. Ward, of Worcester, who was the lowest bidder and to whom the contract was awarded, at $34 605, to the highest bid of $52 350. Mr. Ward, while a contractor of large experience in building work, excavations, etc., had never laid any pipe, and for this reason alone there was some question as to his ability to carry forward the work in the time allowed for it. However, it was finally decided to award the contract to him, largely, perhaps, because — from the nearness in price of all the other bidders as well as the amount of their bids, nearly fifty per cent. above the engineer's estimates — it looked as though there might be a combination among them. At the close of the work, whatever may have been the opinion at the start, there was no question but that this contract had been wisely awarded.

This contract required the work of laying pipe to begin within forty-eight hours after the first carload arrived in Worcester, and to average laying complete nine hundred feet per day. The contractor did not keep up with this schedule, as rainy weather interfered with the work soon after he was well started. In this case, as each day's rain gave Worcester from two to four days additional water supply, such causes of delays were blessings than otherwise. Had the weather been as dry in September as it was in June and July, this work, finished as it was in record time, could have been done in at least two weeks less time. With a rainfall in August of 5.15 in.; in September, 4.10 in.; and in October of 5.48 in., it seemed as though as soon as the city was tied up in contracts and the work under way, rain was almost interminable.

Mr. Ward broke ground August 28, and laid the last piece of pipe October 16. October 17 to 19 were employed in filling the pipe line, when a cracked pipe developed. This was replaced and proved to be the only defect in the entire work. The line was completely filled by the 21st; machinery and pipes were tested out by the pumps on the 22d; and on the 24th of October, in the presence of the mayor, members of the City Council, and others interested in the work, the pumps were officially started by Mr. Frederick H. Lucke, chairman of the water committee of the City Council. It was found that by running one pumping unit, a capacity of about 3 000 000 gal. was obtained; with two units, about 5 000 000 gal., and with the three units, about 6 500 000 gal., thus somewhat exceeding the requirements. Quite likely had all five of the units contemplated been erected and operated at the same time, the additional friction head would have reduced the output to about the 2 000 000 gal. average for which they were guaranteed. The observed pressures when operating were respectively, 187, 204, and 218 lb., with one, two, and three units running.

PLATE II.
N. E. W. W. ASSOCIATION,
DECEMBER, 1910.
SKINNER ON
COBB'S HILL RESERVOIR.

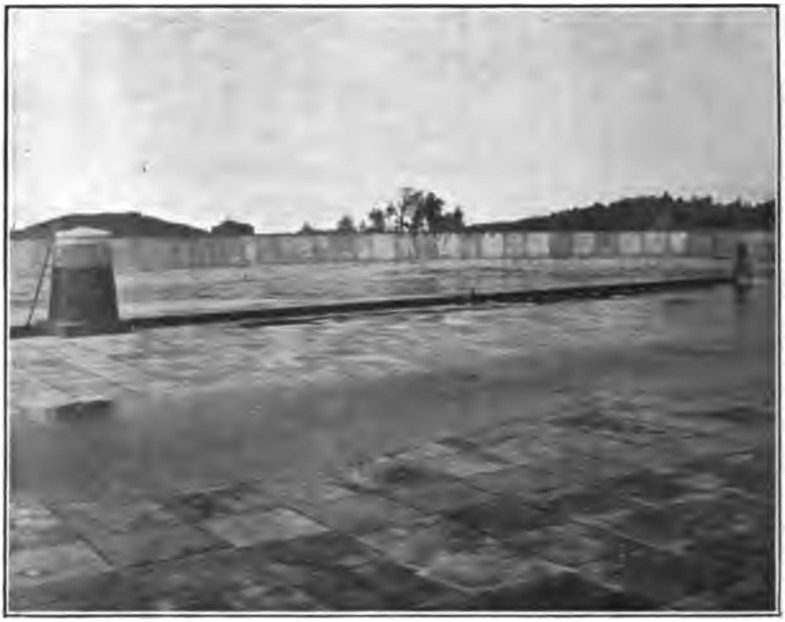


FIG. 1.
WATER BEING LET IN FOR THE FIRST TIME THROUGH SUBMERGED INLET.

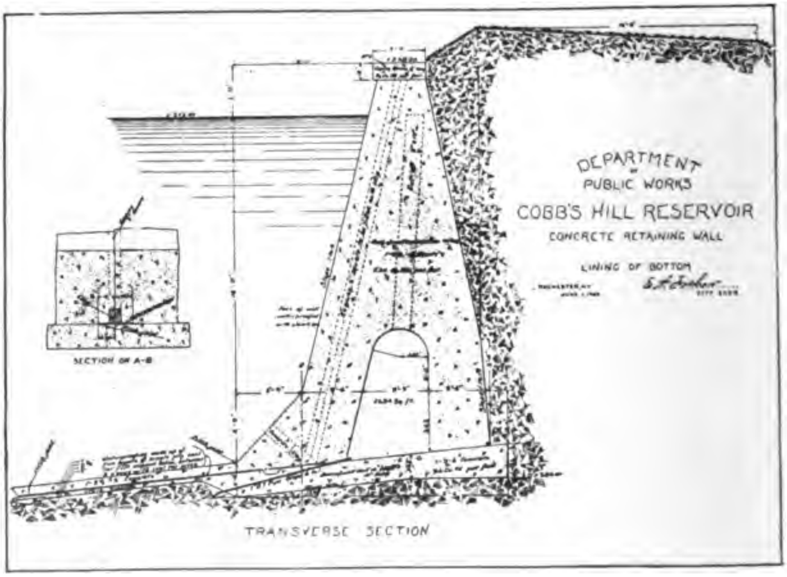


FIG. 2.
CROSS-SECTION OF RESERVOIR WALL.

PLATE VI.
N. E. W. W. ASSOCIATION.
VOL. XXVI.
KIMBALL ON
WATER SUPPLY AT WORCESTER.

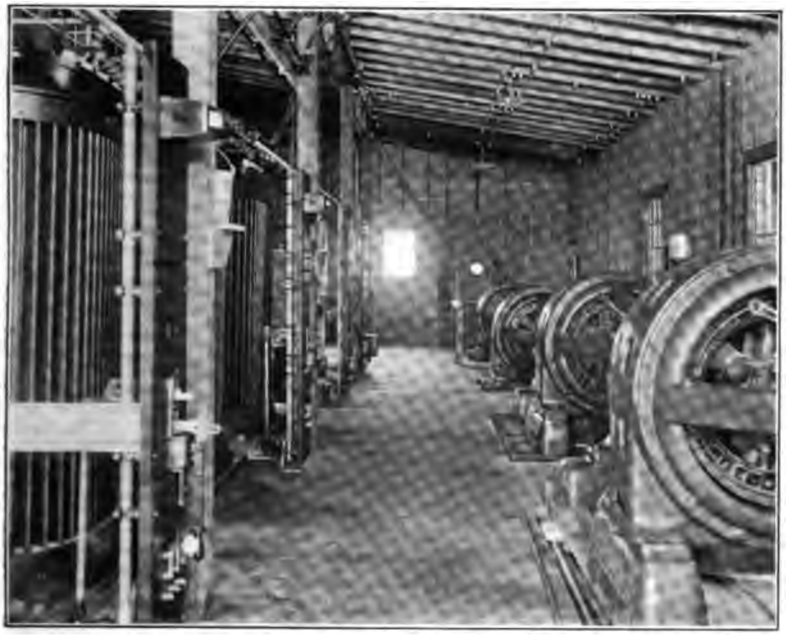


FIG. 1.

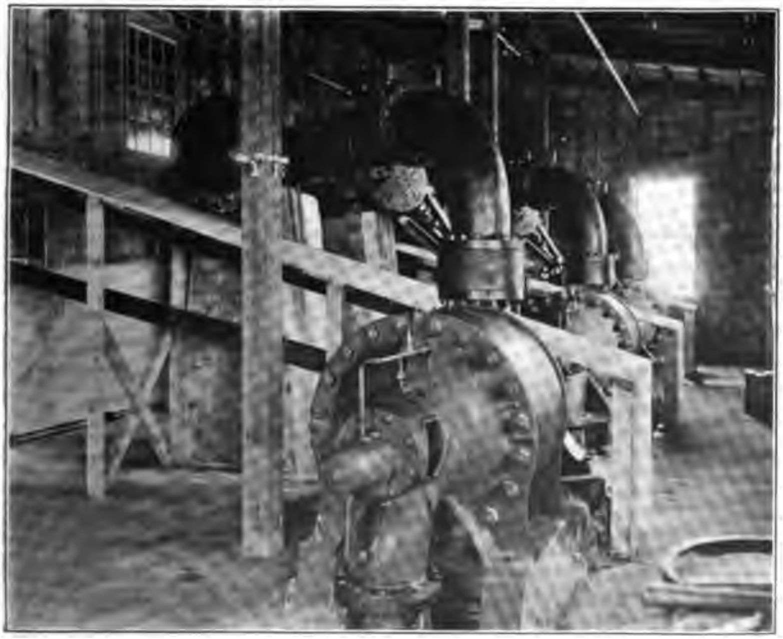


FIG. 2.

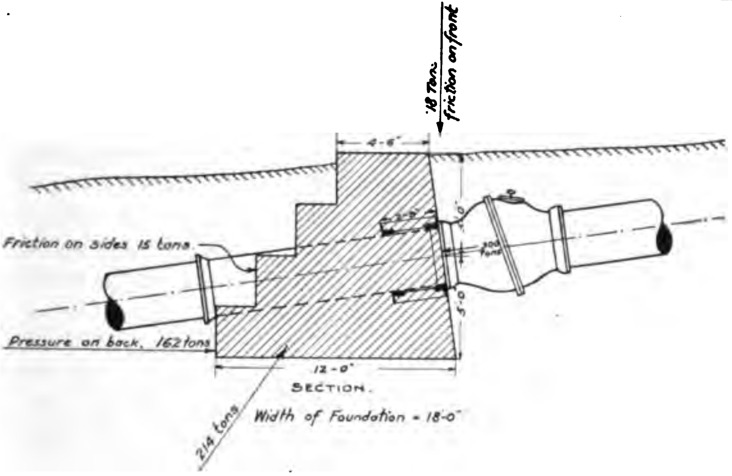
INTERIOR VIEW OF PUMPING STATION, SHOWING MOTORS AND PUMP.

Thus, in two months and ten days after the City Council made the appropriations for this work, it was in excellent running order. As before stated, had weather conditions been favorable and thus required it to have been done, the time could have been shortened to somewhat under sixty days. As it is, when the capacity and weight of the work is considered, it is perhaps a safe assertion to make that it was one of the quickest jobs on record, if in fact it did not break all records. Every one took an interest not only in the work itself but in attempting to make it a record job, and its success is largely due to the lack of friction of any kind between the engineers and contractors. No hair-splitting questions were raised on either side, and whenever difficulties presented themselves they were solved with the one idea of good work and expedition, while the question whether or not it would add to or take away from the profits of any particular contract was not considered or thought of. This job also is a good illustration of what can be accomplished when construction work is unreservedly placed in the hands of engineers unhampered by outside considerations. Civil service rules and city ordinances regulating the employment of labor or the letting of contracts were suspended for this work, and Mr. Allen was given free rein to proceed as he choose; in fact, it was only upon these conditions that he accepted charge of the work. Mayor Logan also fully supported him in all questions arising, thus materially assisting in preserving a full degree of harmony during the progress of this and other portions of the emergency work.

There were only a few engineering problems of moment connected with this work, and these hardly worthy of mention. The use of centrifugal pumps, belt connected to electrical motors and operated under the extreme head it was here subjected to, is certainly unusual in water-works practice, yet in this case it seemed to be a satisfactory combination. In ordering the pipe, knowing from experience that in pipe of this diameter more or less of it was certain to be cast eccentric as to thickness of shell, and further realizing that rejections must be limited to the least quantity consistent with obtaining satisfactory results on account of the limitations in time, the pipe was specified about one class heavier than otherwise might have been used. Even then care was taken in sorting out all pipe as it arrived and distributing it in accordance with its actual thickness of shell on the thinnest side, rather than by its normal class or weight. With an elevation of the pipe line at the reservoir of about 380 and of about 692 where it crosses the divide between the Nashua and Blackstone watersheds, there was sufficient range of pressures to care for about all the varying thicknesses of pipe that arrived. While this method is not economical in ordinary work, its adoption here saved considerable time on this job.

Two 30-in. check valves were used on this line, — one at Summit to avoid emptying Worcester's piping system in case of a break in the 30-in. line, and another near the pumping station to guard against a serious washout in case of accident to the pumps or to the pipes within the building. This latter check valve was set only about 26 ft. from a 45-degree bend where the pipe changes its horizontal direction so as to approach the pump house. To properly anchor this check as well as the pipe line itself at the foot of a rather steep hill, and to take the thrust of any water hammer off the bends, the pumps, and the discharge header within the pump house, a steel grillage or framework was designed and built by the Eastern Bridge and Structural Company, of Worcester. This framework was about 18 ft. long and was set at right angles with the pipe line, being about 2 ft. 10 in. wide along the line of the pipe. It consisted of two girders, one above and one below the pipe, connected together by an octagonal grouping of I-beams so spaced that, with an opening just large enough for the barrel of the pipe to pass through, it engaged the bell of the check valve in nearly all of its circumference. This framework was solidly jacked against the face of the bell of the check and the whole firmly anchored in place by mass concrete. The pressure against this check, when pumping at the rate of 10 000 000 gal. per day was assumed to be about 75 tons, and, to allow for water hammer due to a sudden interruption of the power, the stoppage of the pumps, the blowing off of a bend or from any other reason, the anchorage was designed to withstand four times that pressure, or 300 tons.

All bends, both horizontal and vertical, were thoroughly supported and embedded in concrete, those at and near the pumping


18 Tons friction on front
4-6"
Friction on sides 15 tons.
2-3"
300 tons
4-0"
5-0"
Pressure on back, 162 tons
12-0"
SECTION.
Width of Foundation = 18-0"
214 tons

Wt. of concrete	= 18 × 10 × 8¼ × 140	= 208000	= 104 tons.
" " dirt	= 18 × 7 × 3 × 90	= 34000	= 17 "
	= 18 × 10 × ¾ × 90	= 12000	= 6 "
Friction on front	= 18 × 10 × 200	= 36000	= 18 "
" " 2 sides	= 2 × 8.5 × 9 × 200	= 30000	= 15 "
Direct pressure at back	= 18 × 9 × 2000	= 320000	= 162 "

Total Vertical Forces

Concrete and dirt	= 127
Front friction	= 18
Rear "	= −18
Vertical comp. of load.	48
	175

Resisting Moment at back of Foundation.

Vertical concrete	104 × 6.8	= 707.2 ft. tons.
" dirt rear	17 × 2.0	= 34.0 " "
" " front	6 × 11.4	= 68.4 " "
" friction front	18 × 11.2	= 201.6 " "
		1011.2 " "
Horizontal friction	15 × 3.8	57.0 " "
" pressure	162 × 3.0	486.0 " "
		1554.2 " "
Load Moment	300 × 34	1020.0 " "
		534.2 ÷ 175 = 3.1 ft.

Horizontal Load	300 tons.
" Resistance	177 "
" on Foundation	123 "

Total vertical on Foundation = 175 tons
Area = 18 × 9.3 = 167 sq. ft.
Average unit pressure = 1.05
Max. = 2.10 tons

FIG. 6.

CONCRETE ANCHORAGE FOR STEEL FRAME BRACING TO 30-INCH CHECK VALVE.

station being tied together with clamps, rods, and collars, proportioned to take about double the strain due to the full pumping head.

The Boston & Maine Railroad was crossed twice underneath, and, owing to its requirements as to cover, it was necessary to go to a depth of about 8 ft. to the bottom of the pipe, under their tracks. This in one place, owing to steep banks on the side of their right-of-way, required a cutting of upwards of thirteen feet. In both crossings, water was encountered, and in the deeper one a rather quick-running sand gave the contractor considerable trouble. No interruption of trains was allowed, and the work was carried forward to the satisfaction of all concerned.

This article would not be complete without mention of the work done by the water department of the city while this job was under way. To enable the city to avail itself of this supply, numerous changes in and additions to the pipe lines in the city between Summit and Lincoln Square had to be made, and while these were all in harmony with the well-designed piping plan of the city, except for this purpose all these changes would not have been made for a year or two at least. Between August 14 and October 21, the water department with their own forces laid about 12 860 ft. of 16-, 20-, and 24-in. pipe for street mains, practically the same quantity in length as was laid under Mr. Allen's direction from Wachusett Reservoir to Summit; this in addition to that laid by them on the Eagleville Pond line and also in their regular work, which was not materially interfered with. While this in itself would be something of a stunt for most of us, still those who know the capacity for work of our President can easily understand that with him it was simply good exercise. He also was of great assistance at all times to the various contractors as well as to the engineers, and never was so busy that he could not find time to help them out of their difficulties. To him is due the credit for a large measure of the success of the enterprise.

The pipe line work was under the immediate charge of Mr. Arthur E. Tucker, of the city engineer's office, who also by his handling of the work, particularly with a contractor new to pipe laying, is deserving of much credit.

The city as well as the engineers feel under great obligations to the Stone & Webster Engineering Corporation for options on machinery, pipe, etc., which they turned over to the city without cost, and also for their assistance in every way possible in the carrying out of the work.

Owing to the heavy rains which prevailed during October, it was not necessary to use the supply from the Metropolitan source to any extent, and after it had been thoroughly tried out, pumping about 60 000 000 gal. into Worcester's system, it was shut down and now remains in place, awaiting such other uses as it may be put to. In his address to the City Council at the close of his term of office, on December 27, 1911, Mayor Logan among other things said:

> " I now offer the suggestion that this pipe line be not taken up, but that the pumping plant and pipe line be kept intact and ready for use as an insurance in case of necessity to strengthen the high-service system. If this is not done, the city must begin at once to consider other sources of supply to strengthen the high-service system, which means a large expenditure of money. If an arrangement can be entered into with the Metropolitan Water Board to allow this pumping plant to remain, the city of Worcester may not be obliged to add to its high service for many years to come, and the interest on present investment for an emergency supply will be as nothing compared to the interest charges which the city must provide for if obliged to build additional reservoirs and construct pipe lines to connect with our present high-service system."

It may thus happen that the full value of the work will be repaid to the city, even though it has not yet been necessary to utilize it to any considerable extent.

Nevertheless, based simply upon its proposed and intended use, it can hardly be said that the work was otherwise unnecessary, as the conditions in August and earlier demonstrated the need of just such insurance. The records at Lynde Brook showed, from January 1 to July 1, 1911, a rainfall of only 15.19 in.; — lower than during any corresponding period for years. Further, it may be interesting, as showing what would have happened to Worcester had none of the emergency supplies as furnished been availed of, to call attention to the quantities so yielded to the close of

October, when the rains made further contributions from outside sources unnecessary. These quantities were:

From Pine Hill Reservoir and Asnebumskit Brook	585 000 000 gal.
From wells in Kendall Basin	60 000 000
From Eagleville Pond	62 000 000
A total of	707 000 000 gal.

On October 15 the Worcester reservoirs had

In the two Tatnuck reservoirs	120 000 000 gal.	
In the four Kettle Brook reservoirs	103 000 000	
In the Lynde Reservoir	309 000 000	
A total of		532 000 000
Being less by		175 000 000 gal.

than the emergency supplies had furnished.

Had the months of September and October been as dry as all indications earlier in the season pointed to, Worcester's reservoirs, in spite of all the contributions they could have received, would have been very close to empty when the Metropolitan supply could have been ready for use.

DISCUSSION.

THE PRESIDENT. The water department and the city engineer's department had tried for many years to get an appropriation sufficient to provide this new water supply, but the progress had been very slow. It was hard to awaken the public conscience to the necessity of increasing the supply, so long as water continued to run from the faucets. But conditions had reached such a point, during the fall of 1910 and the winter of 1911, that the speaker was unable to take his regular morning bath with any comfort. Mr. Kimball came to Worcester and assured me that I could do so, but while I believed fully in him I did not do it until I saw that something was doing on the Metropolitan System. It took a long time to get a start. I think for something like seven or eight years we had been trying to get an appropriation, and I doubt very much if the work would have been carried on as far as it has at the present time if it had not been for the shortage of water in 1911. I think the work of developing the emergency supply was done in remarkably quick time, and it shows how men of ability, unhampered by Civil Service rules and, I might say, by politics, can go ahead, when sufficient appropriations are made, and prosecute a work. We are maintaining the pumping plant at the Wachuset Reservoir in condition for operation, and shall do so probably for a year or more, until we have more fully developed our present supply.

THE ECONOMY OF CIRCULAR REINFORCED CONCRETE RESERVOIR CONSTRUCTION.

BY ALEXANDER POTTER, C. E.

[Read by title, February 14, 1912.]

The economy in constructing service reservoirs, circular in shape, for water-works purposes is not, in the opinion of the writer, appreciated as fully as it should be. The circular shape for small reservoirs is not only the safest type of construction from a structural standpoint, but permits also a more economical use of the structural materials. Among the many and, unfortunately, only too frequent failures in reinforced concrete construction, it is rare to note failures of circular reinforced concrete tanks, other than those of badly leaking tanks due to either poor workmanship or poor design, or both.

One of the greatest advantages possessed by the circular section and not possessed by any other is the ability to increase economically the capacity of such a reservoir by simply increasing its depth. This is of great importance in the design of water-works improvements, for it enables the designer to keep down the first cost of construction by building a reservoir of a size sufficient for the immediate needs. As the water consumption increases, it is possible to increase economically the capacity of the reservoir, and at the same time raise the water level to counteract the increasing frictional losses in the distribution system due to increased consumption.

The design of a circular reinforced concrete reservoir appears to be so very simple that the inexperienced designer, carried away by his enthusiasm, is apt to create a structure of larger diameter than the application of the simple formula of tank design would seem to warrant. To him there appears to be no ostensible reason why a structure twice the size of one already built should not offer every evidence of strength and stability if designed in accordance with the formula for ring tension,— a very misleading deduction. The secondary stresses, which in small structures are insignificant, and consequently deemed of too little importance to have attention called to them, increase rapidly with the size of the structure, and only too often limit the size to which any particular type of construction can be adapted.

In a circular reinforced-concrete tank, the writer has in mind the varying tension from point to point in the steel reinforcement due to the difficulty of obtaining a true circle in the field. In a small tank, this is not so serious, as its effect upon the resultant stresses in the steel reinforcement is so slight. To make this point clear, some computations have been made by the writer based on the assumption that in the construction of this type, even with the best of care taken in the field, a variation of a half-inch in the middle ordinate of a 10-ft. chord is likely to occur.

Radius of Tank.	Variation in Radius of Curvature due to a Variation of 1/2 in. in Middle Ordinate of a 10 Ft. Chord.	Corresponding Range of Tension in Steel Reinforcement. Average Unit Tension equals 14 000 Lb. per Sq. In.
Feet.	Feet.	Pounds.
25	23.0– 27.2	12 860–16 200
50	42.8– 60.1	11 950–19 100
100	74.9–150.5	5 910–21 100
200	120.2–632.0	5 820–44 500

This table is not made to accurately show the variation in the tensile stresses of the steel reinforcement for the various diameters given; it does, however, give a fair idea of what may be expected in the variation of the ring tension in a circular structure. It points out the danger resulting from carelessness in constructing a circular reservoir of comparatively thin wall section more than 100 ft. in diameter. For reservoirs of large diameter, however, the economy resulting from the use of a circular section does not obtain to the same extent, and consequently recourse to this type is not so frequent.

The writer's experience would tend to limit the working tension in the steel reinforcement to 14 000 lb. per sq. in. in a small tank, and to 12 000 lb. per sq. in. for comparatively large tanks. A reduction in the allowable steel tension for large tanks is recommended because of the greater range in the ring tension present in the larger structure. It may even be advisable to reduce the allowable unit stresses below 12 000 lb. per sq. in. to keep the excessive local stresses which cannot be avoided within safe limits.

The variation in the tension of the steel reinforcement from point to point, due to the varying curvature of the shell, makes the use of a reinforcing bar with mechanical bond advisable. The reinforcing bars for this reason should also be of as small a size as it is possible to handle economically in the field.

A high carbon steel with an elastic limit of 50 000 lb. per sq. in. can be used to great advantage.

Another difficulty to be considered in the design of a circular reservoir is the tendency to rupture along the line between the inside wall of the reservoir and the base, due to the expansion of the walls by internal water pressure and the consequent drawing away, as it were, from the base of the tank.

A good example of increasing the capacity of a circular reservoir is the enlargement of the distribution reservoir for the village of Suffern, N. Y. This village takes its water supply from Anthrim Lake, formed by impounding a branch of the Ramapo River. The water is pumped from this lake to a distribution reservoir located on the side of a mountain to the north of the village, about 180 ft. above the average village datum. This distribution reservoir, built a number of years ago, is a circular tank 70 ft. in diameter and 10.5 ft. deep, sunk entirely into the ground. The walls forming the sides of the tank are 2 ft. thick, and both bottom and sides are constructed of plain concrete. This reservoir had a storage capacity of 266 000 gal., and cost approximately $4 000.

The recent growth of the village has made it advisable to double the capacity of this distribution reservoir. The old structure, although massive, nevertheless leaked to a considerable extent, especially in the bottom. It was, therefore, decided to line the bottom of the tank at the same time that the sides were being

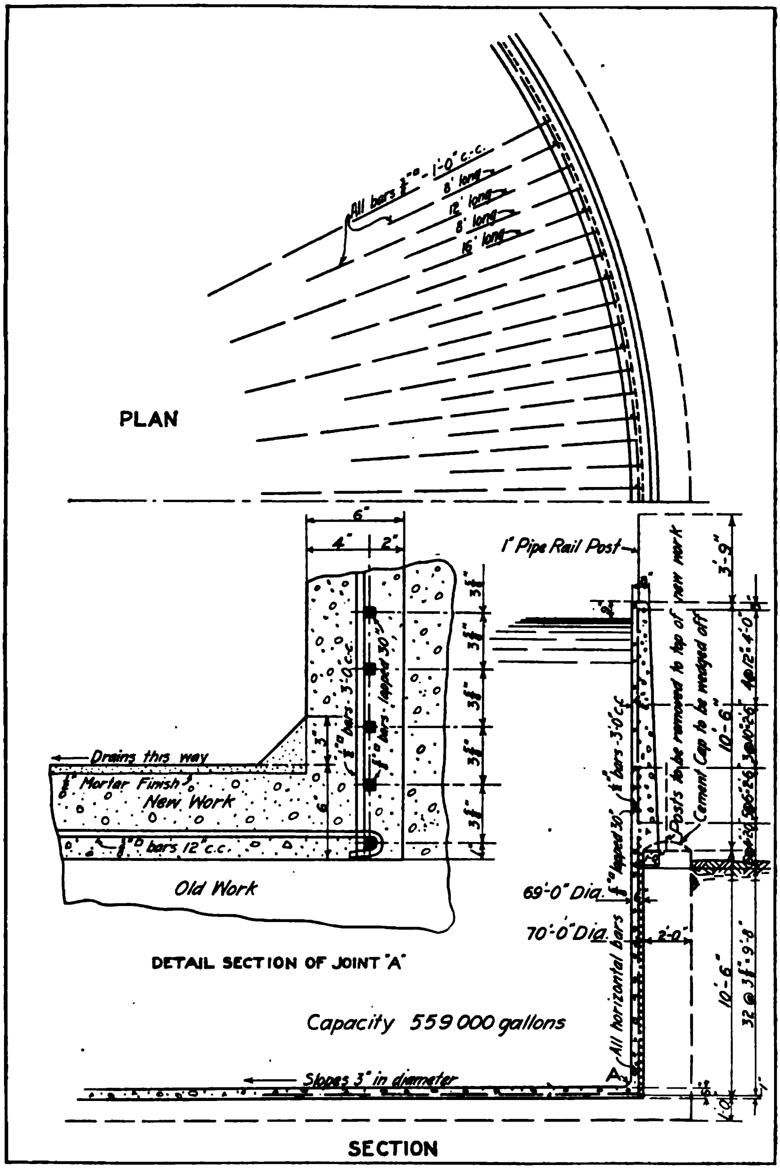


FIG. 7.

RESERVOIR AT SUFFERN, N. Y.

raised. The reservoir as remodeled has an inside diameter of 69 ft. and holds approximately 20 ft. of water, giving a storage of 559 000 gal. The side walls of the old tank are lined on the inside with 6 in. of reinforced concrete. Above the old work, the width of the new work is 12 in., tapering to 8 in. at the top. (Fig. 7.)

The circumferential reinforcement consists of ⅝-in. square corrugated bars, possessing an elastic limit of 50 000 lb. per sq. in. These bars are so spaced that the average unit tensile stress in them does not exceed 14 000 lb. per sq. in.

In designing the lining for the old reservoir, it was assumed that the reinforcement would only have to take care of the increased tension due to the additional depth of 10.5 ft. This is a constant quantity with a full reservoir; consequently the spacing and size of the steel in the lining of the old reservoir is uniform. The existing wall is still relied upon to resist the hydrostatic pressure that it formerly did.

It is not very likely, because of the great daily fluctuation in the water level in this reservoir, that ice pressure will develop to such an extent as to seriously over-stress the reinforced concrete shell, and consequently, no provision has been made for such pressures.

The bottom lining is reinforced with ⅜-in. square corrugated bars, which have their ends hooked over the lowest reinforcing ring. Vertical ⅝-in. square bars, spaced 3 ft. on centers, were used as vertical distributors. Each reinforcing ring is made up of six sections lapped 30 in. and wired. The rings were also wired to the vertical reinforcement at every intersection.

The forms consisted on the inside of vertical sheathing extending the full height of the reservoir, and of horizontal sheathing on the outside. The thickness of the bottom lining varies from 3 in. to 6 in., so arranged as to offer better drainage than was obtained in the old tank.

The reservoir was completed on October 12, 1911, and filled for the first time to its full depth on November 11, 1911. No leaks whatever have thus far appeared. The only precaution to render the reservoir water-tight other than that of using a fairly wet concrete, which was mixed in the proportion of one part of cement to two parts of sand and four parts of ¾-in. broken trap rock,

PLATE VII.
N. E. W. W. ASSOCIATION,
VOL. XXVI.
POTTER ON
CIRCULAR RESERVOIRS.

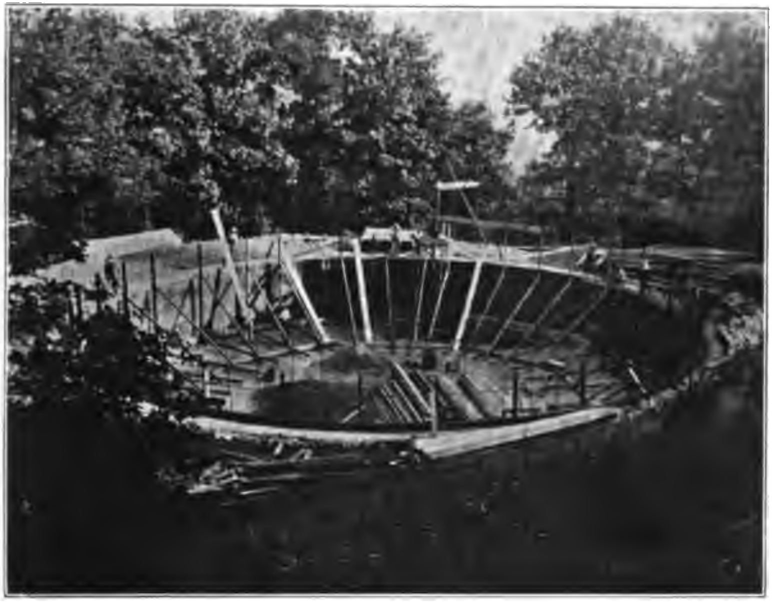


FIG. 1.
PLACING STEEL, SEPTEMBER 20, 1911. RESERVOIR AT SUFFERN, N. Y.

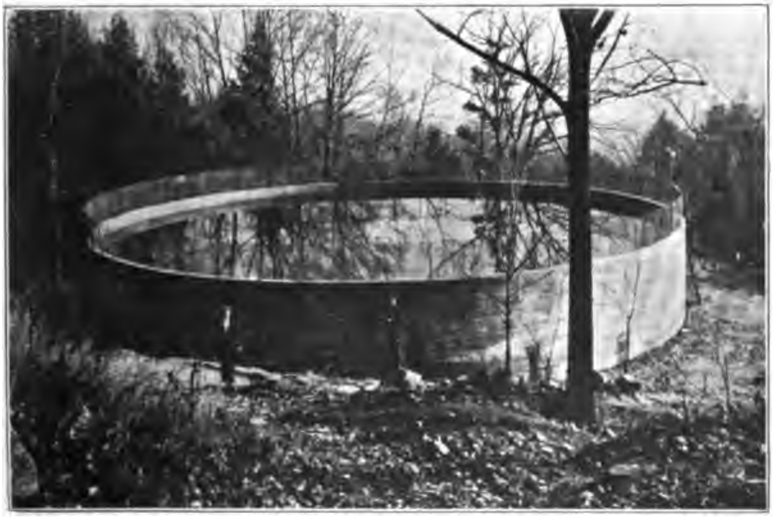


FIG. 2.
FINISHED RESERVOIR, NOVEMBER 11, 1911. ALL EXPOSED WORK NEW CONSTRUCTION.

was to wash the inside of the tank with a semi-liquid Portland cement.

An increase in the storage capacity of 294 000 gal. was obtained at a cost of $2 500, which was the contract price for this work. The location of the reservoir on a steep mountain slope about 180 ft. above the street level added considerable to the cost of hauling the structural material to the site, and, consequently, to the contract price.

SOME WATER SUPPLY PROBLEMS ENCOUNTERED IN THE SEMI-ARID REGIONS OF THE UNITED STATES.

BY CLARENCE GOLDSMITH, ASSISTANT ENGINEER, HIGH PRESSURE FIRE SERVICE, PUBLIC WORKS DEPARTMENT, BOSTON, MASS.

[*Read March 18, 1912.*]

After the serious troubles which the local members of the Association have undergone during the past six weeks, due to the exceptional depth to which the frost has penetrated, it may be somewhat of a consolation to them to have their minds refreshed by a brief enumeration of some of the difficulties along other lines which are encountered by their co-workers in the semi-arid regions of the United States.

The cities of Los Angeles, Cal., Butte, Mont., and Denver and Colorado Springs, both of Colorado, have been selected to illustrate the problems which present themselves to a water-works engineer in a locality where the yearly rainfall is small. The mean yearly rainfall at the above-mentioned cities is less than eighteen inches, while that in New England is slightly over forty-five inches; so it will be clearly seen that the difficulty of developing an adequate supply is much greater than on the North Atlantic coast. A second consideration of almost equal importance in providing an ample supply is the rapid growth of these Western cities, which requires the supply to be developed more rapidly and a larger margin of safety to be maintained than is necessary in the slower-growing Eastern cities.

The city of Los Angeles, supplied by a municipally owned plant, is located a few miles inland from the Pacific coast, and the built-up portion commences just south of the mouth of the San Fernando Valley, the watershed of which comprises 526 sq. miles. The average annual rainfall in the city is 15.93 in., and it increases on the northern slopes of the mountains about the valley to about 22 in. There is practically no precipitation during July and

August, and only 15 per cent. of the annual rainfall occurs in the six summer months. The rainfall is largely absorbed by the vast gravel and débris deposits which line the floor of the valley to a great depth, thus forming a large subterranean lake which appears as the Los Angeles River near the outlet of the valley. This perennial stream of great constancy has an average annual stream flow of from 29 000 000 to 35 000 000 gal. per day. The readings upon which the above figures are based are taken at the hours of greatest transpiration, for it is observed that the flow is some 2 000 000 gal. less when the vegetation is subject to the heat of midday. The total amount which can be derived from all sources of the supply for short periods of time is about 59 000 000 gal. per day.

The city has acquired the exclusive rights to all water, both surface and subsurface, of the entire watershed to the southern city limits. The upper valley was until recent years one of the most productive areas in the state of California, but the courts forbade any pumping of water for irrigation purposes within its confines, basing its decision on the fact that water required for municipal purposes produced the greatest good for the largest number of people. Thereupon agricultural activities practically ceased.

Water is withdrawn at seven points so distributed as to intercept the entire flow; four are within the valley, one at its mouth, and two within the city. Of the first four, the Main Supply diversion is located eight miles northwest of the city, where the stream flow is diverted by a low timber and gravel dam into a concrete conduit about five miles long, which leads to Silver Lake, a distributing reservoir. The greater portion of this conduit was only covered to the spring line until about two years ago, but it never showed any signs of expansion or contraction cracks, although exposed to the heat of the Southern California sun. The estimated minimum supply from this source is 13 000 000 gal. per day. The river disappears in the coarse gravel deposits immediately below the Main Supply diversion, and the subsurface flow is intercepted by six 10-in. wells from 160 to 239 ft. deep. Water ordinarily stands 5 ft. below the surface of the ground, and when the wells are being pumped by an air lift, at the rate of 4 000 000 gal.

per day, into the main supply conduit, during the summer months, the water plane is lowered 25 ft.

At the Crystal Springs diversion, one and a half miles below the Main Supply diversion, the river again appears on the surface and its flow is diverted by a low brush and gravel dam, at the rate of 12 000 000 gal. per day, into the Low Gravity conduit, which extends about five miles to Buena Vista reservoir, and has branches leading to Bellevue reservoir and to the main supply conduit. This supply is augmented by two lines of percolation pipes and an infiltration gallery which extends across the flood plain of the river, and in addition there are six 12-in. wells which can be pumped by air into the conduit line during periods of maximum consumption. The total available supply at this diversion is 23 000 000 gal. per day.

Three miles below this latter diversion there are five 12-in. wells which can furnish about 4 500 000 gal. per day. Ordinarily water stands 10 ft. below the surface, and when being raised by a centrifugal pump into the Low Gravity conduit the water plane is lowered 15 ft.

At the point where the river emerges from the valley, the latter is very narrow and a ledge extends across its bed, between the hills on either side, very near the surface, thus forming a submerged dam which maintains the water plane in the valley. Across these narrows a tunnel, 97 ft. below the bed of the river, extends through solid rock 2 100 ft., and from the surface of the ground are driven nine wells, with slotted casings 12 to 16 in. in diameter, through the ledge into the tunnel, thus intercepting all the underground flow from the valley. About 6 000 000 gal. can be pumped from this source during periods of maximum consumption. From two well fields in the city, containing eight 12-in. wells, 8 000 000 gal. can be raised and pumped into the distribution system when the other supplies are insufficient.

The above-mentioned source of supply was the only one that was available without the expenditure of a large sum, and any development of importance would require several years to render it available. Therefore, the Water Department was compelled to adopt strenuous means in 1905 to conserve the present supply until an ample one could be developed. The growth of the city has been phenomenal. The population in 1900 was 102 479, and in 1910, 319 198, showing an increase of 211.5 per cent. in ten years, and a prospect of a like future growth seemed probable, but it necessarily depends upon ample water supply. In 1905, with a population of 225 000, the average daily consumption was 34 000 000 gal., or a per capita of 151 gal. with 8 800 meters in service, and in 1909, with a population of 300 000, 36 000 000 gal., or a per capita consumption of 120 gal. with 32 700 meters in service.

From the above it will be seen that the population increased 75 000, while the average daily consumption increased only 2 000 000 gal., and practically all the saving can be attributed to the judicious installation of meters and their proper maintenance. Here is a point which should not be slighted and which can be exemplified by this city perhaps better than by any other. The full benefits and best results of the meter cannot be attained without constant attention to their upkeep, and the compiling of accurate records in order to determine the types and makes best adapted to the particular service. The meter and service department is well organized and may well serve as a pattern to any city which is undertaking the general installation of meters.

The question of irrigation during the periods of maximum consumption is of primary importance, and much study has been given to this subject by the officials. One thing has been clearly demonstrated, and that is that the most luxuriant and healthy verdure is not grown on ground which receives the greatest amount of irrigation, but rather that which has received the least, provided it has been intelligently applied. Much depends upon the time of day at which the water is applied, but in general it is safe to say that for the dwelling-house lawn an application divided into two periods, one of thirty minutes in the early morning, and one of thirty minutes in the late evening, produces excellent results. It is to be hoped that more complete experiments can be conducted along these lines, and that the consumers may be educated so that they may be able to produce the maximum results with the minimum amounts of water applied. That this will probably come about within a few years seems certain, for the larger irrigation projects in the West are devoting much time to a study of this phase of the question.

In 1905 the citizens of the city, realizing keenly that the future of the city depended upon an adequate water supply, voted to proceed with a construction necessary to bring water from the Owens Valley to the city. The work entailed by this project is now well under way, and the city will probably enjoy the benefits of an ample supply in 1913. The intake of the Owens River is located 37 miles above Owens Lake, about 258 miles north of the city. The watershed tributary to the river has an area of 2 800 sq. miles, and contains twenty-four mountain peaks covered with perpetual snow, thus insuring an unfailing supply which will be at its maximum during the summer months when the largest amounts of water are used in the city. The water will be brought from the intake at elevation 3 812, through 226 miles of conduit, siphons, flumes, and tunnels, 7½ miles of reservoir, and 12½ miles of natural watercourse, to the San Fernando storage reservoirs, elevation 1 130, which will be constructed 18 miles northwest of the city at the head of the San Fernando Valley. The carrying capacity of the conduit will be 280 000 000 gal. daily, and five equalizing storage reservoirs will be located along the route to insure the continuity of the supply, and several power stations will be erected along the route of the conduit to take advantage of the rapid drops in elevation which occur at several places. At the time of the inception of this project it was one of the largest in reference to the distances involved which had ever been undertaken, and when one recalls the relatively small size of the city, all credit should be given to the engineers and the citizens for attempting the consummation of such a project, which involved such an enormous expenditure.

It may be well to stop here and consider the activities of the water department for the period of the previous seven years. The construction of the new supply works has been pushed as rapidly as circumstances would permit; at times over six thousand men have been employed. The per capita consumption has been reduced by a careful maintenance of the distribution system and the installation of about six thousand meters per annum, and the works within the city have been extended by the laying of about thirty-five miles of main pipe and the installation of 4 100 services each year, all of which has been accomplished with a comparatively small force due to the team work of the employees, which is facilitated by the excellent organization.

The city of Butte, Mont., having a population of about 40 000, lies three miles west of the Continental Divide, and the elevations within the city range from 5 425 to 5 900. Owing to its location at such an elevation there are no large watersheds that are available to furnish an adequate gravity supply. The mean annual rainfall is 15.17 in., with an occasional minimum of 10.29 in. This city has not had an exceptionally rapid growth of population, having increased only 30 per cent. since 1900, but is of special interest from the viewpoint of supply, due to its peculiar location.

The Butte Water Company, operating under a perpetual franchise, furnishes entire supply from five watersheds, sparsely to densely wooded, and uninhabited, which will be briefly described. Basin Creek, which lies south of the city, contains two storage reservoirs, one of which, formed by a masonry dam 250 ft. long and 60 ft. high, at elevation 5 860, has a capacity of 189 000 000 gal.; and the other, about 1¼ miles further up the creek, formed by a timber-crib earth-filled dam, 330 ft. long and 40 ft. high, with a concrete core wall, has a capacity of 64 000 000 gal., at elevation 6 199. The run-off of the watershed is supplemented by the headwaters of Fish Creek, which is intercepted and brought across the Divide in a wooden flume about 7 miles long. This supply feeds the low service through a supply main about 12 miles in length, three fourths of which is 24-in. wood stave pipe, the remainder being 20-in. kalameined pipe. The line will carry about 6 000 000 gal. per day.

A condition which was observed on this watershed may be of interest. The bottom of the lower reservoir was carefully stripped before it was filled, and the surface consists of fine clean quartz sand, while no work was done on the upper reservoir, and the original leaf mold and stumps were covered when it was flowed. In the upper reservoir there is practically no trace of algæ growth, while in the lower reservoir, with its clean bottom, this growth becomes extremely troublesome during certain seasons of the year.

The second and more important source of supply is that of the Big Hole River, which drains a watershed on the eastern slope of the Rocky Mountains, extending southwest to the Bitter Root Mountains. The maximum observed stream flow is 90 000 000 gal. At a pumping station located 25 miles southwest of the city the water is raised from the river at elevation 6 393, against a head of 850 ft., to a masonry standpipe through a riveted steel pipe. The two Nordberg pumps are of very heavy construction to work against this high head; the plungers are 11¼ in. in diameter and the rods and tail rods are 7 in. in diameter. From the standpipe the water flows by gravity about 8 miles to the South Fork Reservoir, which is located in the South Fork of Divide Creek, about 18 miles southwest of the city, and formed by an earthen dam with a concrete core wall. The capacity is 13 500 000 gal. The run-off of the watershed above the reservoir contributes to this supply on an average about 1 000 000 gal. per day. Water from this reservoir flows by gravity to a distributing reservoir within the city, at elevation 5 960, which supplies an intermediate service. The supply line, 18.5 miles long, is of particular interest owing to the method of its construction, which enables wood-stave pipe to be used in a large portion of the line, which only for special features would be under an excessive head. These devices consist of four concrete regulating chambers, each divided into two sections by a concrete weir. In the lower of these sections a float is placed which controls a valve on the pipe entering the upper section, so that when it is desired to curtail the supply coming to the reservoir within the city, a gate is closed immediately outside the embankment, and the water backs up successively in the four regulating chambers, each of which throttles the supply entering it without producing any greater head on the individual sections of the wood stave line than is due to the difference in elevations of the successive weirs.

The fifth source of supply consists of two impounding reservoirs in Yankee Doodle Creek, about 7½ miles northwest of the city, and at the present time it is estimated that this supply can furnish about 3 000 000 gal. per day. The distribution system within the city is very difficult to maintain, as the mines have been excavated under a great portion of it, and the timber bracing is continually settling. Kalameined pipe, a patented article of wrought iron or steel, with a special metallic coating, joined by sleeves with lead joints, is used exclusively, as failures are portended by small leaks rather than by sudden ruptures, as would be the case with cast-iron pipe. As an example of the rapid settlement which has taken place, a 6-in. line laid in a tunnel may be cited. This line is connected through elbows at either end, and about once a year 2 ft. of pipe has to be cut out of the line.

The city of Denver is located on either side of the South Platte River, about 15 miles from the eastern foothills of the Rocky Mountains. Its surface is generally undulating, ranging from elevation 5 134 to 5 482. The population in 1900 was 133 859, and in 1910, 213 381, showing a gain of 59.4 per cent. in the last ten years. The mean yearly rainfall averages about 14 in., with a minimum of about 8.5 in., about 64 per cent. of which occurs between April and August. The yearly evaporation is about 69 in., — practically double that which obtains in Boston. The works which supply the city are owned by the Denver Union Water Company, which owns and controls practically all the water rights which are available for furnishing domestic supply to the city.

The South Platte River furnishes the supply from its surface and subsurface flow at two points outside and one within the city. The flow from a small creek is diverted into a distributing reservoir by infiltration, and that from Bear Creek is stored in one of the storage reservoirs. The river above the city drains an area of 3 910 sq. miles, three fourths of which is of granitic formation and generally sparsely wooded and mountainous, and the remainder prairie land below the foothills.

The precipitation in the mountains is mostly snow which accumulates in the winter months and melts during the months of May and June, producing a high-water period of less than two months' duration, while the low-water period extends over the remainder of the year, during which period the stream flow frequently falls below 20 000 000 gal. per day.

The prairie land when irrigated is extremely productive, so it is not surprising that the stream flow is over-appropriated by the ranch owners and the water company.

The only means to enable a greater amount to be available was to construct a storage reservoir in the watershed; therefore, the

Cheesman reservoir was completed in 1904 on the south fork of the South Platte River, 50 miles south of the city. This storage reservoir is formed by a massive stone masonry dam in a narrow gorge. It is 708 ft. long, 176 ft. thick at the bottom, and 18 ft. thick at the top, and has a maximum height from the stream bed to the top of the dam of 236 ft., a capacity of 25 760 000 000 gal., and an area of 874 acres, at elevation 6 836. The construction of the dam required 80 000 barrels of cement, which was hauled by teams of sixes a distance of 23 miles over a mountain road, and the stone, a gray granite, was quarried within one-half mile of the dam site. The stones are of a uniform thickness of 2 ft., and the mortar joint is 1 in. thick. The masonry work was so well executed that when water is flowing over the spillway, which is located 200 ft. north of the dam in a depression between two mountains, there is no trace of leakage or even sweating on the downstream face of the dam. Water is withdrawn through tunnels driven through the granite mountain north of the dam. Three tunnel entrances at different elevations are controlled by hydraulically operated valves, access to which is provided through man-way tunnels. During the irrigation season, in addition to the water withdrawn for the domestic supply, as much water as is entering in the streams at the upper end of the reservoir must be returned to the river below the dam to take care of the irrigation rights.

This water is carried in the stream bed for about 30 miles, where that portion used for domestic supply is diverted at the Platte Cañon head works into either the Platte Cañon reservoir, or to Marston Lake, through a conduit line. Platte Cañon reservoir is about two miles below the head works, and forms a sedimentation basin of 300 000 000 gal. capacity from which water is passed through slow sand filters having an area of 10½ acres, with a daily capacity of 35 000 000 gal. Water may also be applied to these beds from two small settling basins which are fed directly from the stream.

The supply lines of the system are of exceptional interest. All are continuous wood-stave pipe, are well cross-connected, and the flow through each is recorded by a Venturi meter. The oldest of the longer lines was installed in 1890, and has a length of about 18 miles, in which length there is 44 ft. fall, and the line shows a carrying capacity, by meter measurement, of 8 000 000 gal. per day. There are three other lines of similar length, a 30- and 34-in. line having a capacity of 13 000 000 gal., a 40-in. line having a capacity of 23 000 000 gal., and a 44- and 48-in. line having a capacity of 25 000 000 gal. The continuous wood stave pipe has proved itself well adapted for conduit lines, as the cost of installation is much less than that of steel or of cast iron, not only due to the lower cost of the material, but also to the greater ease with which it can be transported, particularly to points difficult of access. The maintenance is moderate, and in case of failure, repairs can be made much more expeditiously than either on steel or cast iron; and another reason of almost equal importance is that the coefficient of its carrying capacity remains constant. In applying the Hazen-Williams formula one is perfectly safe in using a coefficient of 125 in making calculations, and there are several lines which show coefficients as high as 140. In different parts of the West various woods are used to make the staves — redwood, Oregon fir, and Texas long-leaf pine. The redwood is somewhat too soft to take the tension of the bands without allowing them to cut in too deeply, but the two latter-named woods have proved very satisfactory, and practically all of the Denver lines are made of Oregon fir pine. The wood in the line when properly installed, that is, when all points are below the hydraulic gradient, and suitable air valves are provided on its summits, has a very long life, but the bands, which are the first to fail, have a life of only about twenty-five years, depending upon the quality of the original material, their coating, the care with which they were installed, and the nature of the soil. Experience shows that a rolled thread is preferable to a machine-cut thread, and when they are used it is unnecessary to upset the thread end of the rods in order to secure their full strength.

The remaining supplies do not present any features particularly worthy of note, both being infiltration galleries, one of which delivers by gravity and the other by pumps. All water is filtered, either naturally by infiltration or artificially by either slow sand or mechanical filters, before it enters the distribution system.

The average daily consumption in 1910 was 49 200 000 gal., which, with an estimated population of 213 000, gives a per capita consumption of 229 gal., and the maximum daily consumption is about 70 000 000 gal. No particular effort has been made to reduce the consumption, and there are only about 400 meters in service. Upon first thought it would not appear to be an economic operation of the works to foster so large a consumption, as it has required the installation and maintenance of numerous large conduit lines, but if this water were not used for domestic supply the present water rights would be lost, and it would be well-nigh impossible to secure additional rights which would be required as the city grows. Now any large increase in population can be easily served by adopting measures to reduce the per capita consumption.

The position of the Denver Union Water Company is unique, for although it has been in litigation with the city since the expiration of its franchise in 1910, and prior to that time had many disagreements with the city, it continues to develop the works and expends more than half a million dollars each year, and it always has maintained a system, the efficiency of which is equalled by few cities whose works are either privately or municipally owned.

Colorado Springs is located about 75 miles south of Denver, and has a population of about 30 000. The city lies at practically the same elevation as Denver, and enjoys the same climatic conditions. The supply is derived from a series of watersheds which comprise the southeastern slope of Pike's Peak. Their combined area is 29.57 sq. miles, and that which does not lie above the timber line is from moderately to sparsely wooded. The rainfall on the watersheds varies from about 15 to 30 in., and the snowfall from 97 to about 200 in., but the run-off from the latter is very uncertain, for at these high altitudes it is not uncommon for practically all the snow to disappear without contributing more than a very small amount to the run-off. There are six storage reservoirs which have a combined capacity of 2 194 000 000 gal. Two of these are above timber line, and the higher, at elevation 12 099, is the highest storage reservoir in the world. From the lower storage reservoir water is discharged into Ruxton Creek, and at a point 1½ miles below is diverted into a 16-in. main by a low timber-crib dam at an elevation of 9 241. This line extends for about one-half mile to a reinforced concrete equalizing reservoir from which a 20-in. riveted steel pipe, having a capacity of 17 000 000 gal. per day, follows the contour of the mountains in a gradually descending grade for the first part of its course, and then abruptly descends to a power house located in Manitou, where an available head of 2 400 ft. is used to operate Pelton wheels which discharge into a settling basin, from which point three lines, an 8-in., 16-in., and 24-in., convey water into the distributing reservoirs in the city. The average daily consumption in 1910 was about 8 000 000 gal., which shows a per capita consumption of 232 gal. The maximum occurs during the summer months, and 13 000 000 gal. was used in July, 1910.

DISCUSSION.

THE PRESIDENT. Mr. Goldsmith, I was interested in what you said about the two reservoirs at Butte, Mont., one of which had been stripped and the other not, and one containing bad water and the other good water; have you any theory upon which to explain that?

MR. GOLDSMITH. No, I have not, and the superintendent of the works says that it is beyond him. He was building a reservoir on Yankee Doodle Creek when I was there, and he was taking no chances but was stripping the site. I saw the water myself, and in the upper reservoir it was as clear as could be, while in the lower reservoir, which has this fine quartz bottom, it was simply green with algæ. Mr. Carroll is probably one of the most able waterworks superintendents in the country. He is an Annapolis man, a thorough-going engineer in every respect, but he has been unable to solve the problem.

THE PRESIDENT. Do I understand that the water is drawn from the upper reservoir to the lower?

MR. GOLDSMITH. It flows down a brook for about three quarters of a mile.

MR. RICHARD A. HALE.* I would like to inquire if the life of the wood pipe and the bands, etc., does not depend on the material in which the pipe is imbedded? The reason I ask is that I have recently taken out in Lawrence a wooden penstock which has been in for forty-six years. It was composed of white pine, surrounded by iron bands. The material in which it lay is not clay puddle, but ordinary material, something like river silt, possibly, puddled. There is no indication whatever of decay in the wood, and a section across the iron bands shows them to be as bright as they were on the day on which they were put in. There is apparently no reduction whatever in the section, and every part, the wood and iron, seems to be exceedingly well preserved. There was, of course, no exposure to the air, and I was wondering whether the life of this kind of pipe mentioned by Mr. Goldsmith did not depend very much on the material in which the pipe is laid and upon whether or not it is exposed to air and water and is alternately wet and dry.

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* Principal Assistant Engineer, the Essex Company, Lawrence, Mass.

Mr. Goldsmith. I believe I covered that point. I said that among other things the life of the pipe depends upon the material, the soil, in which it is laid. I would say that the failure of the bands on wood stave pipe up to the present time has practically always been in the threads, and the rolled thread had not been used long enough to have it determined where the failure is hereafter going to be. A few staves in a line would go bad, and when they took those portions out and moved the nuts on the bands, they found that the thread was practically all gone.

Another thing that has been developed by the Denver Union Water Company has been in connection with the putting on of the new bands. They used to be made in a complete circle, and in wiggling them under the pipe a little of the coating would be torn off. Now they are making the bands in two sections, held together by a malleable iron clamp or saddle. That method of construction not only enables them to get the bands around the pipe without injuring the coating, but also to get a great deal better tension on the pipe. They like to lay the pipe in the winter, for the staves are dry, and when there is a little frost on them they drive home better than they do in warmer weather.

The President. Have you any theory or any reason upon which you can explain why the rate per capita at Los Angeles should be so high?

Mr. Goldsmith. It is on account of the rainfall. Only 15 per cent. of the rainfall, the total amount of which is very small anyway, is during the summer months, and there is practically none during July and August. Now Los Angeles is a garden city, you may say. When I was looking up the question of irrigation I found two estates, each of which occupied half a block. The meter on one estate showed that during the year they had used water enough, including what was used for household purposes, the exact amount of which of course could not be determined, to have covered the land to a depth of 14 ft., and, in the case of the other estate, to have covered it to a depth of 7 ft. It is a city of homes. Practically every one owns a little home and has a little garden, and nothing will grow in it without irrigation. That probably accounts for the high rate.

MR. G. C. WHIPPLE (*by letter*). The writer has been very much interested in reading Mr. Goldsmith's paper, and especially that part of it relating to the growth of algæ in the reservoirs of the Butte Water Company. The fact that algæ have given trouble in the reservoir that was carefully stripped before it was filled, and have not given trouble in the upper reservoir, which was not stripped, is in line with numerous instances which have come to his attention during recent years. It is quite evident that our ideas in regard to the control of algæ growths in reservoirs must be modified by these recent observations, and stripping cannot any longer be regarded as a general panacea for this trouble. It is evident that there are many conditions other than that of providing a supply of organic food material that are involved in the problem. Therefore, if the author could give us further information in regard to the nature of the algal growths and the physical and topographical conditions of the reservoirs, he would be adding to the knowledge that must be accumulated before an adequate theory as to the cause and control of algæ growths can be advanced.

Since the early work on the subject of algæ growths was undertaken by members of this Association twenty years and more ago, comparatively few investigations in this country have been published and the science of limnology has been allowed to wane. Meantime, however, some extensive investigations have been made in Europe, especially in Scotland, where questions of temperature, currents, etc., have been investigated in detail. References to this foreign literature may be found in the files of the *Internationale Revue der Gesamten Hydrobiologie und Hydrographie,* which has been published since May, 1908. In this country the most important references to the subject are the report of Messrs. Allen Hazen and George W. Fuller on " The Relation of Reservoir Stripping to the Improvement in Quality of Water, " published in the Annual Report of the Board of Water Supply, City of New York, 1907, and the monograph of Dr. Edward A. Birge and Chancey A. Juday on " The Dissolved Gases of the Water and their Biological Significance," published in Bulletin XXII of the Wisconsin Geological and Natural History Survey.

The writer hopes to review all of this literature during the near future, and thus make it available to the members of the Association, hoping that it will stimulate anew the interest in the general subject of limnology.

METHODS OF THAWING FROZEN SERVICE PIPES, AND DISTRIBUTING THE COST THEREOF.

TOPICAL DISCUSSION.

[*March 13, 1912.*]

Mr. J. J. Prindiville.[*] Mr. President, there is one question I would like to bring up here this afternoon which is of vital interest to the smaller departments, and that is, how to treat the services entering from the street mains to the houses of the consumers.

This last winter, which has probably been as cold as any winter in the past twenty-five years, we have had a great deal of difficulty from freezing. There has been very little trouble with the mains, but there have been from 150 to 200 services frozen on private grounds. Those services are paid for, when they are put in, by the owners, and when they are frozen the owners call on the department to thaw them out. Now the question is as to whether the expense of doing that should not be borne by the owners rather than by the department. The reply to that is that the services were put in, in almost every case, under the direction of the department, and the owners say that under those circumstances, as the department assumed the responsibility for putting them in, it should pay for the expense of thawing them out. This becomes quite a serious question when we have a winter like the past one, and so I would like to bring the matter up for discussion to see if we cannot get some information as to the best way to treat the subject and learn the opinions of the members as to whether the department or the owners of the services should pay the charge for thawing them out. Another question is as to the best method in use for thawing out these service pipes.

The President. I would say that we have had a great many frozen services in Worcester this year, and they were laid by the Water Department. We have taken the attitude that where a service was frozen in the street the city would assume the responsibility, but if the freezing clearly started in the cellar we would charge the expense of thawing to the consumer. That seems to be perfectly fair.

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[*] Member and Secretary Water Commissioners, Framingham, Mass.

MR. PRINDIVILLE. What would you do if the house was 100 ft. from the street and the service was frozen under the lawn?

THE PRESIDENT. I should hold the consumer responsible, if the freezing was on his premises. Oftentimes services are put in when the grade of the lawn has not been established, and in those cases the Water Department uses the best information it has, and if it turns out that the owners do not fill in as much as they had planned to do, so that the frost gets down and the pipe freezes, we do not think the department should be held responsible. But if the grade is established, and the department puts the service in, we think we are morally bound to take care of it, unless the freezing begins in the cellar and works out through the cellar wall. Then we think that the consumer should pay for thawing the pipe out.

MR. EDWIN C. BROOKS.* I would like to ask how you determine that it starts in the cellar and works out.

THE PRESIDENT. It isn't difficult to determine that in a good many cases. Sometimes when we start thawing we will get the water through before we have gone more than two or three feet beyond the wall.

MR. BROOKS. The stand that we have taken in Cambridge has been that we were to furnish water to the sidewalk cock, and that the owner is responsible for what happens from the sidewalk cock to the house. I wish some of you gentlemen who have put on goosenecks and some of those contraptions that are supposed to take up the expansion and contraction of service pipes had to wiggle the thawing coil around through some of them. I think it would convince you that, although they might have advantages, they certainly add to our difficulties. And, another thing. Why can't there be some uniform method of putting services into houses? Why can't they come in above the cellar bottom, and not go into a little well, as they often do, and then run back under the concrete floor of the cellar? It is very difficult to get a coil into the pipe under such conditions. It seems to me that before we live a great many years longer we ought to adopt some uniform method of putting in supplies which will provide that the supply shall enter the cellar two or three inches or more above the finished cellar bottom, and that the stop and waste valve shall be accessible. It would add very much to the ease of thawing out supplies if something of that sort could be adopted. Then there is another thing: to have ample water-ways in sidewalk cocks and in corporation cocks adds very much to the peace of mind of the person who is trying to get a coil through, instead of having one of these little oblong openings which the coil will scarcely go through. There are a good many of these little details which, if they were attended to, would add very much to our ease in getting along, and if we are to have many winters like the past one, it would seem as though they would have to be provided for.

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* Superintendent of Water Works, Cambridge, Mass.

Mr. Frank A. McInnes.[*] With approximately 100 000 services in Boston, we have had about 200 frozen. I have a list of deposit slips, and have to settle whether we shall pay the money back or keep it. In the majority of the cases it is the same old problem as to where the freezing started, — whether on the premises or in the street.

With regard to the method of thawing the pipes out, I am satisfied that there is one best way, and that is to have your own electric plant, consisting of motor and generator of say 25-kilowatt capacity, which you can put on an electric truck or on a wagon and move from place to place. We have lost a large amount of time both with the A.C. and D.C. current in getting connections, grounds, etc., and have decided that we must have our own outfit. I have talked with some of the water-works supply men and have asked them to get up something and put it on the market before next winter.

The next best thing to electricity is steam under pressure, live steam carried right from the boiler into the pipe.

Mr. Brooks. I would suggest a small portable tubular boiler operated by either gasolene or kerosene under pressure to boil the water that you use in your coils, so that when you start thawing out you will be sure to have plenty of hot water. In many of the poorer districts, when the supplies are frozen, a man will have to go from house to house to get a pail of hot water. There are but few hot water boilers in the vicinity. He may find a teakettle of water on the stove, but the woman will want it herself, and then the man will have to run to the nearest engine house or schoolhouse or some place of that kind with the hope of getting some water there. It is much more satisfactory to have a small boiler from which you can put a steam jet into your pail and keep the water boiling hot, so it can be used in the coil when it is hot instead of lukewarm.

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[*] Division Engineer, Sewer and Water Division, Boston, Mass.

There is another idea that I have had in mind, and that is whether it is not possible for us to use the spiral steel pipe that is rolled in a spiral and locked together. They use it for tube blowers, and I understand it is made in sizes as small as ⅜ in. It seems to me that would stand rough usage and not be liable to be pulled apart in pulling it out of the services, and would be very much better than the ordinary block tin coil that we are using now.

Mr. McInnes. In Boston we use small boilers delivering live steam under 4 or 5 lb. pressure through a ⅜-in. lead pipe into a service or through a ⅝-in. pipe into a larger pipe.

Mr. Prindiville. The question which troubles me still remains, Mr. President, and that is, who is to pay? In most departments the rules provide that the services must be put in subject to the approval of the department, — either put in by the department or subject to the approval of the department. Now if they freeze, how are you going to decide, as has been said, whether the freezing begins at the street end or at the house end? The pipes are frozen and the owners come to you for relief. At one time this winter we had so many of such cases that it took us two weeks to get around. In a number of instances there was severe sickness in the houses, and it was a very great hardship not to be able to use the waterclosets and bath-rooms.

Now suppose you say to the owner that he has got to pay to have his service thawed out and that you will require a deposit. The owner refuses to pay, on the ground that you have got to furnish him with water. You are already charging him for it, and you have got to furnish it to him, he claims, and you are not giving it to him. It seems to me that there is quite a big question for us to consider. It may be a legal question as to whether you can take the ground that you will not thaw the service out and yet will charge the owner for water. In order to get some light on this subject, and the matter is one which is of particular importance to small departments, I would suggest that a committee of three or five, whichever number you see fit, be appointed to take this matter up and make a study of it and recommend to the Association the best method to adopt as to who must pay the bills for thawing frozen services. It does not seem right, in one aspect of it, for us to stand by and say we will not thaw them out, and yet at the same time charge a minimum rate for the water.

The President. Our way in Worcester would be to thaw out the service and then to thresh out afterwards the question of who shall pay for it. Get the water running in the first place, for you will then be on the safe side, and take up the question of payment later. I think it would be very difficult to establish any uniform practice for the different cities and towns. It seems to me the question would be very largely a local one.

Mr. Prindiville. If you eliminate the charge in one case, you have got to do it in all cases.

The President. Under the same conditions, yes. You have got to be consistent. I have learned that you cannot safely make any exceptions.

Mr. Frank C. Kimball.* To answer the gentlemen's question specifically, it seems to me that it must depend entirely upon the conditions under which service pipes are laid in the particular place. Some departments assume the laying of the pipes to the cellar wall, charging a certain price per foot, the cost, or whatever it may be, and laying them as they see fit, using the kind of pipe they may choose and at such depth as in their opinion is necessary. I think in such a case as that there is hardly any question but what the expense of thawing the pipe should be borne by the department. On the other hand, some departments run merely to the curb or to the street line, and it is for the owner to get a plumber and bring the water into the house. Even though that be done subject to the approval of the department, I think in such a case it would be for the householder to pay the expense of thawing out the pipe, because, while it is subject to the department's approval, it is not beyond the province of the property owner or his plumber to do a better job than the department requires, although they seldom do it. So, as I say, in all cases I think it is the way the rules or regulations of the department read which will largely govern as to whether the department or the property owner pays the bill. As to drawing an exact line where the freezing begins, whether in the cellar or at the main or at the property line, you cannot always do it.

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* General Manager, Commonwealth Water and Light Company, Summit, N. J

MR. WALTER H. RICHARDS.* Mr. President, I agree with Mr. Kimball. I think if the city lays the pipe across a man's lawn into his house, the city should be at the expense of thawing it out in case it freezes, for the city assumes responsibility by laying it.

To determine just where the freezing starts is very difficult. I think it is a very rare case in which you can do it with absolute certainty. I have one case in mind where the pipe froze solid right out to the curbstone and the service did not freeze at all, although it was not laid any deeper than the pipe to the sidewalk was.

MR. ARTHUR F. BALLOU.† We began by using live steam for thawing pipes. The city of Woonsocket is responsible for the pipe to the curb line.

We investigate each case of freezing that is reported to us. If we get water at the curb we at once shut it off so as to drain the private part of the pipe and prevent the freezing from working back into our part of the pipe. If the service is off a big main, one of the principal arteries of the city, we put in steam and thaw out the ground so as to protect the main pipe.

The requests to be thawed out became so numerous that we had to begin to use electricity because we could do the work so much quicker. We thawed the consumer's part of the pipe and ours at the same time, and we bore the expense, if both parts of the pipe were frozen. But where we had water at the curb we notified the consumer that we should expect him to pay us the cost, and nobody demurred at that. They seemed to expect to pay it.

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* Engineer and Superintendent, Water and Sewer Department, New London, Conn.

† Superintendent of Water Works, Woonsocket, R. I.

We have had quite a lot of trouble this past winter. We had over one hundred frozen services, and everybody realized that we were working hard to remedy the conditions, but that we were up against a pretty tough proposition. Perhaps that had something to do with the attitude of the consumers. They treated us very kindly, perhaps differently than they would have if there had only been five or six cases. There was only one man who was dissatisfied, so far as I know, and he had only been taking water about four weeks. He is wiser now, and I think if he had had the water for several years he would have realized the conditions better. Nobody demurred against paying the expense, and of course there were so many pipes frozen that the charges when they are divided are not going to be exorbitant. We did our best to protect our mains and to keep the consumers supplied with water.

I think in Woonsocket we look at the question of the service pipes a little differently from any man who has spoken here to-day. Anybody who applies for permission to make connection with our mains and to take water is given the privilege of making the connection. It is a privilege. We do not guarantee to give uninterrupted service; we cannot do that; and our consumers all take the water under those conditions. We do our best, of course, to keep the water flowing in the mains, but as far as any liability on the part of the city is concerned, we do not admit it. As a general thing, the people accept the service in that spirit. We have been very fortunate, we have not had many interruptions, and nobody ever attempts to be disagreeable. In case a main breaks they realize that we get to work and fix it as soon as possible, and they are perfectly willing to wait, and, of course, they are more so if they have a neighbor on another street who has water.

Mr. McInnes. One way to avoid trouble would be to adopt the method used by the largest city in the country, New York, and that is to have absolutely no responsibility beyond the main. That is the rule in New York City; they have charge of the main pipe and everything else is up to the owner.

Mr. Brooks. I think, Mr. President, that considerable trouble might be avoided if services were not laid under walks leading up to the houses. It is frequently the case that a service pipe runs under the walk, which is kept shoveled off in the winter time, and, of course, the frost then has a chance to go down much deeper than it does on the lawn, which is covered with snow and where there is a coating of grass.

MR. FRANK L. FULLER. Mr. President, I would like to inquire what the cost of thawing out service pipes by an electric current is?

MR. MCINNES. I can tell you exactly what it cost us this year. but as it was all emergency work the data is really of little value. A great deal of time was lost trying to make connections, in running secondary wires and in waiting; we were actually working but a small part of the time. The entire cost of thawing divided by the actual number of services thawed, including one elevator pipe which took a half a day, amounted closely to $19. The total cost divided by the total number of services we thawed and tried to thaw, loosing a great deal of time on some without actual work, amounted to $14 apiece. With your own outfit, the expense is only a matter of a dollar or two at the outside.

MR. BROOKS. What do you use for power?

MR. MCINNES. With the A. C. current we used a 50-kilowatt transformer and a water rheostat working often without a ground. We got our primary on one side connected and let the ground take care of itself. I want to emphasize the fact that our cost of thawing is absolutely no criterion of what it should cost, because it was emergency work and we let nobody wait.

MR. FRANK E. WINSOR.* I do not think that I am qualified to speak on this matter, but as Mr. Fuller has asked the question as to the cost, I might say that in White Plains, N. Y., the Westchester Lighting Company has made a business of thawing out frozen services, of which there have been a great many during the past winter. The rule in force by the water department places the responsibility for the house service entirely upon the householder, and the department has no interest in thawing out service pipes. If such pipes freeze, the householder or owner of the property must arrange for thawing them out. The charge for thawing, where there are no particular complications, was fixed in the early part of the season as $7.50 and was later increased to $10 per service. In Tarrytown, N. Y., the same company has charged $15 per service during the past winter. Special prices have been made for large jobs.

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* Department Engineer, Board of Water Supply, City of New York.

Mr. McInnes. The owner of the outfit which was working for us told me that in the adjoining town of Norwood he thawed twelve services at once, so the expense would naturally be a good deal less than our cost. What we paid is no criterion, for our frozen pipes were isolated, in all parts of the city.

PROCEEDINGS.

MARCH MEETING.

HOTEL BRUNSWICK,
BOSTON, MASS., March 13, 1912.

President George W. Batchelder in the chair.

The following members and guests were present:

HONORARY MEMBER.

Desmond FitzGerald.— 1.

MEMBERS.

S. A. Agnew, J. M. Anderson, C. H. Baldwin, A. F. Ballou, L. M. Bancroft, F. A. Barbour, G. W. Batchelder, F. D. Berry, A. E. Blackmer, E. C. Brooks, G. A. Carpenter, E. J. Chadbourne, J. C. Chase, J. H. Child, M. F. Collins, John Doyle, E. R. Dyer, E. D. Eldridge, J. W. Ellis, G. T. Evans, A. N. French, F. L. Fuller, M. L. Fuller, A. S. Glover, Clarence Goldsmith, F. H. Gunther, R. A. Hale, F. E. Hall, M. F. Hicks, H. C. Ives, W. S. Johnson, Willard Kent, F. C. Kimball, G. A. Stacy, Morris Knowles, C. F. Knowlton, F. A. McInnes, N. A. McMillen, A. E. Martin, John Mayo, F. E. Merrill, H. A. Miller, William Naylor, F. L. Northrop, T. A. Peirce, J. J. Prindiville, W. H. Richards, L. C. Robinson, A. L. Sawyer, C. W. Saxe, G. A. Stacy, W. F. Sullivan, J. L. Tighe, E. J. Titcomb, W. H. Vaughn, R. S. Weston, Elbert Wheeler, William Wheeler, F. I. Winslow, G. E. Winslow, F. E. Winsor, H. V. Macksey, T. G. Hazard, Jr. — 63.

ASSOCIATES.

Builders Iron Foundry, by F. M. Connet; Darling Pump and Manufacturing Company (Limited), by H. H. Davis; Glauber Brass Manufacturing Company, by S. S. Freeman; Goulds Manufacturing Company, by R. E. Hall; Hersey Manufacturing Company, by Albert S. Glover and W. A. Hersey; Lead Lined Iron Pipe Company, by T. E. Dwyer; Ludlow Valve Manufacturing Company, by H. F. Gould; H. Mueller Manufacturing Company, by G. A. Caldwell; National Meter Company, by C. H. Baldwin and J. G. Lufkin; Neptune Meter Company, by H. H. Kinsey and R. D. Wertz; Norwood Engineering Company, by C. E. Childs; Pratt & Cady Co., by C. E. Pratt and M. J. Kane; Platt Iron Works Company, by F. H. Hayes; Rensselaer Valve Company, by F. S. Bates and C. L. Brown; A. P. Smith Manufacturing Company, by F. L. Northrop; Thomson Meter Company, by E. M. Shedd; Union Water Meter Company, by F. E. Hall; Water Works Equipment Company, by W. H. Van Winkle; Henry R. Worthington, by Samuel Harrison. — 24.

GUESTS.

I. P. Wood, inspector, Marlboro, Mass.; Henry C. Page, Arthur E. Tucker, Worcester, Mass.; Robert E. Whittle, Arlington, Mass.; John E. Minos, J. E. Parker, E. F. Hughes, Boston, Mass.; Ivers M. Low, superintendent water works, Weymouth, Mass.; Herbert W. Hunt, Reading, Mass.; Howard V. Allen, water commissioner, East Greenwich, R. I.; D. R. Howard, Woonsocket, R. I.; George E. Stimson, Rochdale, Mass.; W. F. Woodburn, Philadelphia, Pa.; John A. Thompson, A. E. Barrett, Lowell, Mass.; Frank S. Newell, John F. Browning, and John J. Mack, water commissioners, Salem, Mass. — 18.

The records of the last meeting were read by the Secretary and approved.

The Secretary announced that the Executive Committee had this forenoon voted to hold the next annual convention at Washington, D. C., during the third week in September.

Applications for active membership, properly endorsed and recommended by the Executive Committee, were presented from Charles E. Perry, Canajoharie, N. Y., engaged in sewer and water-works construction and design; Philander Betts, Newark, N. J., chief engineer Public Utilities Commission, State of New Jersey; and for associate membership from Francis H. Coffin & Co., Scranton, Pa., general sales agents for hydraulic supplies, particularly machine-made wood stave water pipe.

On motion of Mr. Thomas A. Pierce, the Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so, they were declared duly elected members of the Association.

Mr. Frank C. Kimball, civil and hydraulic engineer, Boston, Mass., read a paper entitled "How the Water Emergency at Worcester, Mass., was Handled in the Summer of 1911, together with a Brief Description of Worcester's Sources of Water Supply." The paper was illustrated by stereopticon views. The President, Mr. Batchelder, spoke briefly upon the subject of the paper.

Mr. F. A. McInnes, for the Committee on Standard Form of Specifications for Cast-Iron Water Pipes and Special Castings, which was requested at the last meeting to consider and report as to the advisability of making some changes in the standard specifications, presented the following report:

Mr. President, — I am sorry that the chairman of our committee is not here, but I have the results of our labors and with your permission I will read the report:

MARCH 13, 1912.

NEW ENGLAND WATER WORKS ASSOCIATION:

In 1902 this Association adopted a Standard Form of Specifications for Cast-Iron Water Pipe and Special Castings which has been used during the past ten years by members of the Association and other users of cast-iron pipe throughout the country; in the meantime the American Society for Testing Materials and the American Water Works Association have each adopted standard specifications differing slightly from those of this Association.

While our specifications have well served their purpose, your committee believe that the time has come when certain changes should be made if they are to continue, economically, to make for the best results, and it therefore recommends that they be revised. Your committee realize from past experience that the questions to be considered will undoubtedly entail a large amount of work, involving the making of computations and drawings; it is, therefore, suggested that the matter be placed in the hands of a new committee of five, to be appointed by the President, and that the committee be authorized to expend not exceeding $500 for assistance in the preparation of its report.

DEXTER BRACKETT,
F. F. FORBES,
F. A. MCINNES,
Committee.

That is all that the committee has to say on the matter.

On motion of Mr. George A. Stacy, the report of the committee was accepted and its recommendations adopted.

The President subsequently appointed Messrs. Frank A. McInnes, Dexter Brackett, Frank A. Barbour, William R. Conard, and George A. King as members of the committee.

Mr. Clarence Goldsmith, assistant engineer, High Pressure Fire Service, Public Works Department, Boston, Mass., read a paper entitled " Some Water Supply Problems Encountered in the Semi-Arid Regions of the United States," and dealing with the water supplies of the cities of Los Angeles, Cal.; Butte, Mont.; and Denver and Colorado Springs, Colo. The President and Mr. Richard A. Hale made certain suggestions and asked certain questions which were answered by Mr. Goldsmith.

The President announced that a letter had been sent out to various water departments with a view to obtaining opinions as to the proper depth to which water pipes should be laid in various localities. He said that in Worcester the pipes were laid to the depth of about 4½ ft. to the center of the pipe, and this year the frost had gone down 6 ft.

EXECUTIVE COMMITTEE.

BOSTON, MASS., March 13, 1912.

Meeting of the Executive Committee of the New England Water Works Association at the rooms of the Association, 715 Tremont Temple, at 11.30 A.M.

Present: President George W. Batchelder, and members Frank A. McInnes, Millard F. Hicks, Morris Knowles, Robert Spurr Weston, George A. Stacy, Lewis M. Bancroft, George A. King, and Willard Kent.

Three applications for membership were received and recommended for admission, namely:

For members: Philander Betts, chief engineer, Public Utility Commission, State of New Jersey, Newark, N. J.; Charles E. Perry, civil engineer, Canajoharie, N. Y.

For associate: Francis H. Coffin & Co., Scranton, Pa.

A communication from Mr. B. N. Simin, civil engineer, of Moscow, Russia, together with notes on and blueprint of fire hydrants, was received and the Secretary was instructed to express to Mr. Simin the appreciation and thanks of the Association for his interest in the matter. The several papers were referred to the Committee on Fire Hydrants.

The President announced the result of the vote of the members of the Executive Committee on place for holding the next Annual Convention to be as follows: viz., Washington, D. C., 5; Philadelphia, Pa., 3; New York, 3; and the individual expense of attending convention in the places named to be approximately as follows: Washington, $37.50; Philadelphia, $30, and New York, $30.

On motion of Mr. Bancroft, seconded by Mr. McInnes, it was voted that the next annual convention of the New England Water Works Association be held in the city of Washington, D. C.

Voted, on motion of Mr. Weston, that the date of the next annual convention be Wednesday, Thursday, and Friday of the third week in September.

Voted, on motion of Mr. Knowles, that Mr. King and Mr. Kent be a committee to investigate and report on the expediency of visiting the Cape Cod Canal on the occasion of the June Outing.

Adjourned.

WILLARD KENT, *Secretary*.

New England Water Works Association.

ORGANIZED 1882.

Vol. XXVI. **September, 1912.** **No. 3.**

This Association, as a body, is not responsible for the statements or opinions of any of its members.

STATE CONTROL OF THE DESIGN AND CONSTRUCTION OF DAMS AND RESERVOIRS. ACTUAL PRACTICE IN EASTERN CONNECTICUT.

BY CHARLES E. CHANDLER, C.E.

[*Read September 18, 1912.*]

The Connecticut statutes passed in 1878 provide for the repair of unsafe dams as well as for approved design and construction of new dams. This paper is confined to the actual operation of the law in regard to new dams in Eastern Connecticut with which the writer was connected as engineer for the owners or for the state, or of which he had special knowledge.

The essential part of the law so far as this paper is concerned is as follows:

> "SECTION 4803. *Approval of Dams.* — Before any person or corporation shall construct a dam or reservoir in a locality where life or property may be endangered through the insufficiency thereof, the plans and specifications for such dam or reservoir shall be submitted to a member of said board of civil engineers, who shall examine the ground where the dam or reservoir is to be built and the plans and specifications therefor; if he approve the same, he shall issue a certificate authorizing the construction of such dam or reservoir. No such dam or reservoir shall be constructed without such approval and certificate.
>
> "SECTION 4804. *Inspection of Work; certificate of approval.* — The engineer under whose authority a dam or reservoir is being constructed shall inspect the work or cause the same to be in-

spected at least three times before completion; and if he shall be satisfied that such dam or reservoir has been built in a substantial and safe manner, in accordance with the plans and specifications approved by him, and is strong and secure, he shall issue a certificate approving the same, which certificate shall be recorded in the office of the town clerk of the town in which such dam or reservoir is located. No such dam or reservoir shall be used until such certificate is obtained and recorded."

All the expense of approval and inspection is borne by the owner of the dam.

The first experience that the writer had with the practical operation of the law was about twenty-three years ago, when he made the plans for a dam for a manufacturer under the specific direction of the local member of the State Board. As engineer he made no surveys, did not see the site and exercised no discretion whatever, and never saw or heard of the dam afterward. Presumably it was built and is standing.

For the second dam the writer made a survey of the ground, but prepared the plans and specifications in accordance with the direction of the State Engineer. The owner at first refused to have grades and lines given for starting the construction work, on the theory that the contractor had agreed to build the dam and the owner had nothing further to do. On the refusal of the contractor to begin the work until lines were given on forms erected by him, the owner caused such lines to be given. The dam was built without other inspection than that given by the State Engineer.

When the reservoir first filled with water the whole spillway section went downstream, leaving the remainder of the dam, which, like the spillway, was of stone masonry, standing unharmed.

It should be remembered that the law does not require the State Engineer to visit a dam more than three times.

Later the dam was rebuilt in accordance with the same plans and specifications, under the constant supervision of an inspector, and it is still standing after more than twenty years has elapsed.

In another case the writer made plans and specifications for a dam for the owner under the direction of the State Engineer and the dam is in good condition at the end of twenty-five years.

In a case coming under his observation plans were approved by the State Engineer, who declined to approve the construction because no spillway was provided. A spillway was added later when its necessity had been demonstrated, fortunately without damage.

In another and very important case that the writer had opportunity to know about, the plans and construction were approved by the State Engineer. A portion of the spillway, about two hundred feet in length, went out on account of an insufficient foundation, and was replaced by a timber construction. The State Engineer took no part in this replacement, deciding that it was "repairs," and that approval of repairs was not required by law.

This State Engineer had a record of at least nine dams, two of which failed in part, and in neither case was the failure due to the plans or specifications. No very serious damage to other than the owners occurred as a result of these failures. The damage to the owners was about $80 000.

In about the year 1891, on the death of the former incumbent, the writer was appointed a member of the Connecticut State Board of Engineers, having supervision of dams and reservoirs.

In regard to small proposed dams, the question as to necessity of state control in specific cases has sometimes arisen. The writer declined to decide these cases. If the owner wished to run the risk of building without approval, the writer saw no reason for objecting. If the owner preferred to be on the safe side and obtain approval, his attitude was unchanged.

When plans and specifications were submitted for approval, the writer first gave attention to the dimensions of the spillway and learned the area of the watershed. If the spillway provision fell much short of that recommended by Fanning, a study was made of the character of the watershed, the capacity of other spillways on the same stream, and the amount of storage on the stream above the point in question, and such information as was available as to floods on the stream in question and nearby streams. In the light of such knowledge a capacity somewhat less than Fanning's was sometimes allowed.

When the capacity of the spillway was decided, it was required that the spillway masonry be of sufficient dimensions to bring the resultant within the " middle third " of the base with the water at level of top of abutments with no water downstream from the dam.

Other things too numerous to mention were required.

In many and perhaps in the majority of instances the plans were made by competent engineers and the dams built under careful supervision. In such cases the duties of the State Engineer were merely nominal.

In other cases the plans and specifications presented called for dams that were wholly inadequate. In these cases new plans and specifications were made to the acceptance of the State Engineer, sometimes after many conferences.

When competent inspectors were constantly on the work, and the State Engineer had faith in the owner and builder, five visits only were made; the first to examine the site, the last to inspect the finished structure, and three at intermediate times.

In cases where builders and engineers were inexperienced in dam building, and especially when the only engineer employed was also the contractor, more frequent visits were made.

In one case the work was visited two or three times a week while the masonry was in progress.

While the writer has been a member of the State Board, he has had his own plans for dams approved by other members of the State Board whose practice has been substantially like that herein described. On one occasion, the State Engineer required an increased width of embankment.

In one case a water privilege was sold subject to the provision that any dam erected thereon should meet the approval of an engineer employed by the grantor, who was the owner of the adjoining downstream privilege on which was a large amount of property likely to be damaged in case of failure of the dam.

The writer was employed by the grantor, and another member of the State Board represented the state. Quite a serious controversy arose, in which several engineers took part. The final result was a much safer dam than the owner would have built had he depended on his own engineer.

The following interesting question arose on the dam finally built. Is a dam having a substantial amount of earth embankment and depending on non-automatic gates to pass freshet water "built in a substantial and safe manner . . . and . . . strong and secure" in the meaning of the statute?

The State Engineer approved the plans, but the writer declined to do so under the deed, but after certain changes recommended by him had been made in the plans, his employers entered into an agreement allowing the building of the dam in the manner above described.

Such dams are much used in Michigan where the water level in ponds on large watersheds is wholly controlled by Taintor gates, there being practically no spillways except a narrow space through which to float logs.

The twenty-five or more cases in the writer's experience may be divided into three classes.

First: When plans, specifications, and inspection are under the supervision of competent engineers in the employ of the owner. In this class state control is merely nominal.

Second: When the engineer employed by the owner is inexperienced in dam building. Generally such engineers cheerfully modify their plans at the request of the State Engineer, but not always.

Third: When the owner depends on the contractor for his engineering.

In both the second and third cases, the work of the State Engineer has been very important.

In the opinion of the writer the law has done much good in Connecticut, but it is deficient in many respects, among which are the following:

1. There is no provision for a hearing of interested parties.
2. There is no provision for filing plans and specifications, so that any one can tell how a dam is to be or has been built.
3. The State Engineer cannot take the initiative in the case of unsafe dams already built.

DISCUSSION.

PROF. PHILANDER BETTS.* I may say that the state of New Jersey because of the interest aroused by the failure of the dam at Austin, Pa., enacted a law last winter, which is now on the statute books, providing that the State Water Supply Commission shall have supervision over all dams, those already built and those to be built, and hereafter no dam can be erected in the state of New Jersey for any purpose without having first the approval of the State Water Supply Commission.

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*Chief Engineer of the New Jersey Public Utilities Commission.

Since the dam gave way at Austin there has been a certain amount of feeling of uncertainty in some places, in the northern part of the state, where most of the dams are located that could be considered sources of danger to the communities, and on the part of the Public Utilities Commission we have already sent an engineer to inspect three of these dams. They were earth dams, and only one of them was located in a position where it was really a potential danger to any number of persons. An examination of it showed that no dam ought to be constructed in the way that this particular one was, but under the existing conditions it did not appear to be sufficiently dangerous to take any action in the matter.

The Public Utilities Commission in New Jersey is charged with requiring every public utility to keep its property in such condition as to enable it to render safe, proper, and adequate service. There is some difference of opinion as to whether that power and that responsibility extend to the keeping of a property in such condition as to prevent its becoming a danger to outsiders. The jurisdiction of the Public Utilities Commission is usually supposed to be exercised, at least in accordance with the New Jersey law, in such a way as to provide that the users of the service of a particular company will receive safe, proper, and adequate service, without reference to whether the existence of the plant of the particular company may be a serious danger to others than the users of the utility. The law requires that the company must keep its property so as to furnish good service, but the public utilities law does not extend to putting on the Utilities Commission the responsibility of seeing that the particular plant is not in itself a source of danger because of its existence, that is, either to the customers themselves or to others.

Nothing has yet been done by the Water Supply Commission in connection with the administration of the law. New Jersey, with the exception of the northern portion, is a fairly flat state, and the flatter portion of it, the eastern and southern sections, have a number of small ponds. In two cases the available head is about forty feet. One of them, located at Millville, is so located with reference to the town that the breaking away of the dam would result in serious damage to a very considerable portion of the town. Most of the ponds, however, are small, furnishing power for grist mills, etc., ranging from five to, say, nine feet head. With the two exceptions noted above, they are small in area, and below them lie no communities that would suffer in case the dam gave way altogether.

About three weeks ago I was looking over a dam about twenty miles southeast from Camden, which is not now connected with the operation of the company in question. This dam had been in existence as an earth dam for a great many years. The old mill had been owned by father and son. They had installed a small steam-driven electric plant which included a 50-h.p. turbine, but after they came to operate it they found there was not water enough to take care of it, so that as a source of electrical energy it did not amount to very much. Some examination, however, was made of the drainage area, and property was obtained and a scheme for a new dam laid out. The whole matter was left in the hands of the young man by the father. Neither father nor son was an engineer, and the dam was built entirely by guesswork, and bore some resemblance to the foundation wall of a building. It lasted for a day and a half. The experience there, while no damage was done to others than the owners of the property, really showed the necessity for some sort of supervision over that sort of thing. Of course you may say that a person has a right to spend his money and waste it in whatever way he likes; but as a rule these things are potential dangers and ought to be, I think, under some kind of supervision.

In the northwestern portion of the state, the hilly portion, the population is more scanty, and the dams that are found there are used only for the operation of grist mills, with the exception of two. One supplies the power for a small electric plant of perhaps 75 h.p., located at Branchville, Sussex County, and the other is located at the mouth of Paulins Kill where it empties into the Delaware River opposite Portland, Pa. At that location they have available a capacity for about 800 kw. The dam which is at present in place, was put in to replace a dam which was carried out a few years ago. The number of dams that have been carried away in these comparatively unimportant situations rather goes to show that enough study has not been given to the proper construction of dams before they were actually constructed.

Mr. Alexander Rice McKim:[*] I did not come here to make an address. I only heard of this meeting yesterday afternoon, and I thought that if a busy lot of men, as engineers usually are, could leave New England at the busiest season of the year to come to Washington, they would be a body well worth seeing. I thought they must be mostly millionaires if they were able to get away at this time. That is one reason why I came, because I wanted to see you; and besides, I thought I might be able to pick up a little information.

The Conservation Commission of New York has a Department of Inspection of Docks and Dams, but it is practically a department simply for the inspection of dams, for the law gives us jurisdiction only over structures which impound water, and so far I have not been able to find any docks which impounded water. Previous to the passage of the conservation law, there was absolutely no inspection, or no record kept of dams in the state of New York, but since July, 1911, all dams which are to be constructed or reconstructed or renewed in any way have had to have the approval of the commission. The law also provides that if there is any dam which the Commission considers dangerous, or in any way a menace to life or property, they can cause it to be repaired or removed. There is, moreover, a penalty of five hundred dollars a day for owners who do not carry out the instructions of the commission. We have therefore the hearty coöperation of all the owners, which is a very important factor. Without this penalty clause, the law would be a farce and the department useless.

I happen to have here the requirements for plans to be submitted to the Conservation Commission, and as this is right in line with this discussion, I think it would be in place to give it here:

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[*] Inspector of Docks and Dams, New York State Conservation Commission.

"Before the erection, reconstruction, alteration, or extension of a structure for impounding water, or a structure within the natural and ordinary high-water mark of any stream, the owner, lessee, or the authorized agent, engineer, or builder employed by such owner or lessee for the proposed structure, shall submit, in duplicate, to the Conservation Commission complete specifications and prints, in plan, elevation, and section, showing the location of the dam, the flow line of the impounded water, and the ownership of the property affected, the exact nature of the foundation bed, the character of the materials to be employed, the size and the location of the discharges, the general and special features of the dam, and such dimensions as are necessary for the calculation of the stresses and the erection of the structure. The size of drawings should be 24 in. wide by 36 in. long, with a space inked in to print white on the lower right-hand corner of the tracings 3 in. by 6 in. long for the stamp of approval. When the design is approved by the commission, one set of specifications and prints will be returned, duly stamped and signed. After the site has been cleared and prepared, before permission can be granted to commence erection, the name and a statement of the experience of the inspector for the work must be sent to the commission, a sample of at least one half a cubic foot of sand and twenty cubic inches of each of the other materials to be employed in the structure must be sent to the commission, and the site must be inspected by the commission."

You will see that after the plans have been approved there are yet three conditions to be fulfilled.

First, a statement of the experience of the inspector on the work is required. I have found several defective dams in which the defects should have been detected if competent inspectors had been employed who knew anything at all concerning materials and the work, and, upon inquiry, found that such was not the case. So I put this clause in in order to bring to the mind of the owner or officials that it is necessary for the man who inspects the work to know something about it, and, if he has to sit down and write such a statement, it just sets him thinking.

Second, the materials must be inspected. These materials are sent to the State Laboratory for inspection, which is one of the best equipped and managed laboratories in the country. Generally, the cement and stone give us little trouble, but we have great difficulty in some parts of the state in getting good sand. The failure of the dam at Port Henry was due entirely to the use of a sand the particles of which were coated with a fine, insoluble loam, which prevented the setting of the cement.

Third, The site must be inspected. This is to be sure that the dam has a good foundation and that it is properly prepared according to the plans and to our requirements.

With regard to the organization, our commission is fortunate. We have under us about two hundred game wardens and forest fire patrolmen, who cover the whole state of New York. These are furnished with blank forms on which each is to report on the dams in his district. They fill these forms out to the best of their ability and send them in; some of these reports are excellent, and others are not as good, but they at least locate the dams of the state, for no one knows at present where they are or anything about them. The men are also instructed, if they find a leak, or a crack, or anything which looks dangerous, or if there is any apprehension concerning the safety of any dam, to report it at once.

Besides these men I have a number of assistants who are going systematically through the different counties doing the above work. We also receive many letters and petitions requesting examinations, and some of these are from owners. These three sources supply us with information concerning the dams of the state. Wherever there is a complaint, or a probable weakness, I give the dam a personal examination. If dangerous, I request the water lowered to what I consider safe limits until the dam has been reinforced to the satisfaction of the commission; and generally this is sufficient.

Last January our commission adopted a code for dams, but it has not been printed yet, because we are trying it out first. As we ascertain the reasons for weakness in or failure of dams, we change the code to correct these features or conditions. A number of the requirements are entirely new, and I think they may be of interest to this body. If you will permit me, I will read just a few of the new clauses, leaving out the standard clauses with which you are all familiar:

" Rock excavation must be done with very light charges of explosives, but, wherever blasting is liable to injure the bed upon or against which the masonry is built, excavating must be done by wedging and barring or other approved methods."

I find that a favorite method of making the necessary channels and trenches in the rock is to put in dynamite and blow everything to pieces. I have seen them blast good rock all to pieces, where there was a natural channel a few feet off, simply because on the drawing it showed a channel underneath one part of the dam. Explosives of all kinds, I think, are dangerous in the hands of men who do not understand their power, as they are liable to open up fissures. That is one of the reasons why so much water is lost underneath the dams and we have an under-upward water pressure.

Then as to the calculations for the water pressure, we require that —

> " All dams must be stable at any section and under all conditions. Dams must be figured to resist the pressure of the highest possible flow, both perpendicularly against the upstream face and the probable upward pressure under the dam; and also to resist the probable pressure of ice.
>
> " For thin walls the compression on masonry must not exceed 10 tons per square foot. For solid masonry dams of over 150 ft. in height with the best of work and materials, and erected under the supervision and inspection of experienced engineers, the compression on upstream face may be 18 tons per square foot and on the downstream face 14 tons per square foot."

This is allowing a pretty good pressure on large masses of concrete which will be well built, as, for instance, the work of the Board of Water Supply of New York City.

> " No allowance shall be made in the calculations for steel in solid masonry dams."

I do not believe in building a thin dam and then putting rods in to take up the necessary tension to hold it down. Because, in order to stretch the rods sufficiently to take up the stresses calculated, the dam must move, and when once it commences to move, — nothing can stop it. A gravity system must stand in place by gravity and gravity alone. If engineers wish to put in steel to bind the whole together, or as an extra precaution in anchorage, well and good.

> "In reinforced concrete beams, the allowable compression in the concrete should be 500 lb. per square inch, the ratio of the moduli of elasticity of steel to concrete shall be taken as fifteen, and the ratio of the area of steel reinforcement to the effective area shall be one and one-half per cent."

I find that in reinforced concrete dams even the best of companies are putting 14 000 lb. per square inch on their steel, and others 16 000. The above clause reduces the allowable tension to 8 000 lb. I believe, with further investigation, that it is probable that we will decrease instead of increase the above allowable stresses on steel and concrete.

> "The reinforcement at any section parallel to the shear must be sufficient to take up the shear by means of diagonal bars, as well as to provide for tension due to the bending moment by means of bars in the lower or upper flanges, wherever such tension occurs."

The shear is given little and often no consideration in the calculations. If the lower side of a dam is sufficiently reinforced to take the tension, designers often think that is all that is necessary. But a reinforced concrete beam, even with a few thousand pounds stress on the steel, will crack to the center. So the concrete cannot take up the shear and the iron has got to provide for it and should in part therefore be placed diagonally.

For sand we allow as much as seven per cent. by weight of clay and loam, "if fine and divided and all but two per cent. easily dissolved in water."

Now, as to spillways:

> "All dams must be provided with durable spillways of sufficient size to prevent the highest possible flow escaping over any part of the dam where no provisions have been made for such escape, or the highest flow coming within the distance of the top as prescribed under earth dams; and without depending for relief upon the operation of any mechanism not automatic and approved of by the highest authorities."

I do not believe in sluiceways to relieve a flood. The man you are depending upon is never there; he is sick, or something else when the flood comes. And, when sluiceboards get a foot or two of water over them, they cannot be raised, even if the watchman is present and active.

Another thing. What is the sense in having a spillway to take care of the flood and then filling it full of flashboards fastened down? So we specify:

> " Flashboards may be used in spillways up to a height of one half the clear height of the spillway, if the flashboards are not fastened in any way and if they will float off by their own buoyancy when overtopped by the water. The uprights, against which the flashboards rest, may be fastened to the spillway, but the top of the upright should be inclined slightly downstream."

I think I will not take up any more of your time now. The other provisions in this code you will get in due course, when the code is printed. I think it will be up to the times and will contain a great many things which have never been put in specifications before; and when it is printed I hope to have the coöperation of engineers all over the country, and if there are any defects we should like to have them pointed out. This is not the work of one man; we want the consensus of the opinions of engineers so as to get the very best standard for the state of New York. I thank you very much for your attention.

Mr. T. H. McKenzie. Is this a part of the standard specifications you send to engineers?

Mr. McKim. This is from the code that we are getting out for their use.

Mr. McKenzie. And you send it to engineers who are planning dams before they plan them?

Mr. McKim. That is the idea.

Mr. McKenzie. Speaking of gates, do you allow the use of Taintor gates operated by power?

Mr. McKim. That is a question. I do not like the idea myself of relying entirely on Taintor gates, although we have passed them. If these gates were automatic and reliable, or could be so made, I would have no objection, but when they have to be operated by mechanism which may be out of order at the critical moment, or the person who is going to operate them may not be there, I do not approve of them.

Mr. McKenzie. I wanted to know what you said in your specifications.

Mr. McKim. That is what we say, — that they cannot rely on any mechanism for relieving the flow which is operated automatically.

Mr. Arthur A. Reimer. I would like to ask Mr. McKim if the code from which he has quoted is in such form that if we were to write to him as individuals we could get at least some of the principal points from it.

Mr. McKim. Certainly; I have many letters every week of that kind. If you will state the character of the dam, whether stone or earth, I will give you everything we have bearing upon it, and will be glad to do so. I am doing it right along.

Mr. Reimer. I am not living in New York, and I was simply wondering if we, as members of the Association interested in engineering subjects, could get it.

Mr. McKim. I would be glad to send the whole code to you as soon as the commission has it printed.

Mr. Reimer. It seems to me that we have had a very good line of specifications or provisions given us by Mr. McKim, and some very happy ideas, and I wish that he might allow the Association to have a copy of the full code so that it could be incorporated in the report of these proceedings, at any rate. Could you furnish it to us?

Mr. McKim. I will ask permission to do that. It has not been given out as a whole yet, and there is a power above me which must be consulted. I am willing personally to give out all I can, whenever I can.

Walter C. Simmons, Esq.* (*by letter*). The following is the Act creating the Commissioner of Dams and Reservoirs of the State of Rhode Island. Although it has been amended in a few unimportant points, it is practically as the act now stands on the statute books.

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* Commissioner of Dams and Reservoirs, Providence, R. I.

GENERAL LAWS OF THE STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS.

CHAPTER 124.

(AS AMENDED TO APRIL 13, 1906.)

Of the Inspection of Mill Dams and Reservoirs.

Section 1. The governor shall at the January session of the general assembly in the year 1901 and in each third year thereafter, with the advice and consent of the senate, appoint some competent civil engineer to be commissioner of dams and reservoirs. The person so appointed shall hold his office until the first day of February in the third year after his appointment. Any vacancy which may occur in said office when the senate is not in session shall be filled by the governor until the next session thereof, when he shall, with the advice and consent of the senate, appoint some such person to fill such vacancy for the remainder of the term.

Sec. 2. The commissioner of dams and reservoirs shall make a thorough inspection of every dam and reservoir in the state as often as may be necessary to keep himself informed of the condition thereof; and shall make and keep a record of the result of such inspection, with whatever knowledge he shall obtain in reference to each dam or reservoir, and shall make an annual report of his doings in his said office, in the month of January, to the governor.

Sec. 3. Every person owning, maintaining, or having control of any dam or reservoir shall, upon written request therefor, furnish to the commissioner of dams and reservoirs as full, true, and particular description of such dam or reservoir as may be practicable; and shall, as soon as may be after said request, cause to be made all such necessary surveys, plans, and drawings thereof as may be required by the commissioner.

Sec. 4. No dam or reservoir shall be constructed or substantially altered until plans and specifications of the proposed work shall have been filed with, and approved by, the commissioner.

Sec. 5. The commissioner, on application made to him in writing by any person owning or representing property liable to injury or destruction by the breaking of any dam or reservoir, or on such application made by any mayor or board of alderman of any city, or by the town council of any town, on account of danger of loss of life, or of injury to any highway or bridge therein, from the breaking of any dam or reservoir, or, without such complaint, whenever he shall have cause to apprehend that any dam or reservoir is unsafe, shall forthwith view and thoroughly examine such dam or reservoir. And if in the judgment of the commissioner such dam or reservoir be not sufficiently strong to resist the pressure of water upon it, or if from any other cause the commissioner shall determine such dam or reservoir to be unsafe, or if in his judgment there is reasonable cause to believe that danger to life or property may be apprehended from such unsafe dam or reservoir, the commissioner shall determine whether the water in such reservoir shall be drawn off in whole or in part, and what alterations, additions, and repairs are necessary to be made to such dam or reservoir to make the same safe, and shall forthwith, in writing under his hand, notify the owner or person having control of such dam or reservoir to cause such additions, alterations, and repairs in said dam or reservoir to be made within a time to be limited in such notice; and may order the water in said reservoir to be drawn off, in whole or in part, as said commissioner may determine.

Sec. 6. If the owner or person having the control of any dam or reservoir, who shall be required to draw off the water, or a portion of the water, in any reservoir, or to make alterations in any reservoir, or repairs thereon or additions thereto, in the manner prescribed in the preceding section, shall not forthwith proceed to comply with such requirement, or shall not prosecute the work, when commenced, with reasonable expedition, the commissioner of dams and reservoirs shall make out a complaint in which he shall set forth the condition of the said dam or reservoir, and the steps he has taken to cause the water to be drawn off therefrom and for the alteration or repair thereof, or to have additions made thereto to secure the safety of such dam or reservoir, and the default of the owner or person having control thereof in drawing off the water, repairing, altering, or in making addition to such dam or reservoir, and that the safety of life and property is endangered by such default, and shall subscribe the same, and deliver such complaint to the attorney-general or to the assistant attorney-general, who shall present the same to the appellate division of the supreme court, with a petition in the nature of an information, *ex-officio*, praying that the person owning or controlling such dam or reservoir may be required and ordered forthwith to comply with the requirements of the commissioner of dams and reservoirs theretofore made in the premises, or with such other orders as may be made by the court, to secure all persons having reasonable cause to apprehend injury to life or property from the unsafe condition of such dam or reservoir. Upon the filing of such petition a citation shall issue to the person controlling or owning such dam, commanding him to appear at a time and place therein named, to show cause, if any exists, why the relief prayed for shall not be granted; and the court shall summarily proceed to hear the said cause; and upon hearing the parties, or by proceeding *ex-parte*, if the respondent fail to appear, the court may pass such order and decreee in the premises as will effectually secure the persons interested from danger or loss from the breaking of the dam or reservoir complained of; and the court may enforce such orders and decree by injunction, process for contempt, by sequestration, or by such other process as may be applicable in such cases.

Sec. 7. The commissioner to be appointed under the first section of this chapter may employ a consulting engineer in any specific case in which the exigencies of the case may require it. The compensation of such consulting engineer shall be allowed by the governor, and be paid, upon the order of the state auditor, out of any money in the treasury not otherwise appropriated.

Sec. 8. All necessary expenses incurred by the commissioner of dams and reservoirs in the discharge of his duty shall be paid from the funds of the state, upon presentation of the proper vouchers approved by the governor: *Provided*, that not more than three hundred and fifty dollars shall be expended by said commissioner in the aggregate in any one year. For the purpose of carrying this act into effect the sum of three hundred and fifty dollars, or so much thereof as may be necessary, is hereby appropriated out of any money in the treasury not otherwise appropriated; and the state auditor is hereby authorized to draw his orders on the general treasurer from time to time for such sums as may be necessary, upon the presentation of properly authenticated vouchers.

Sec. 9. Said commissioner may, in the discharge of his duties, enter upon and pass over private property without rendering himself liable in an action of trespass.

CERTAIN LEGAL ASPECTS OF WATER-POWER DEVELOPMENT IN MAINE.*

BY CYRUS C. BABB, M. AM. SOC. C. E.,
CHIEF ENGINEER, MAINE STATE WATER STORAGE COMMISSION.

[*Read September 18, 1912.*]

INTRODUCTION.

The writer approaches this subject with considerable hesitancy, as he makes no pretensions to a training in law. He was impelled to look into the law of waters by the numerous requests that were received in the office of the Commission regarding the legal features of water-power development in the state of Maine. Furthermore, certain questions occurred to him in his consideration of a policy to be adopted by the state for the development of its water-powers, or, as the Water Storage law requires, " to report a comprehensive and practical plan for the improvement and creation of such water-storage basins and reservoirs as will tend to develop and conserve the water-powers of the state."

Extracts from a number of decisions have been noted that have been of great interest to the writer as bearing directly on the subject-matter, and it is believed will be of general interest to engineers, especially to those practicing in New England. The quotations given below are more in the nature of an introduction to a proposed bill providing for state supervision of the construction of dams, the regulation of storage reservoirs, and the taxation of water-powers.

A large number of court decisions have been read, but the citations given below are intended to represent general principles and not special or unusual cases. Full references are given, so that the facts on which the decisions were based can be looked up, and the subject pursued further if desired, as each case generally has references to other similar ones.

FEATURES OF LAW.

Water-power and water-storage developments in Maine have been based mainly, in so far as legal features are concerned, on the

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* A table of contents for this paper will be found on page 226.

Colonial Ordinances of 1641–47; the so-called Mill Act; the common law of waters; to a lesser degree, the act relating to the improvement of marshes, meadows, and swamps; the several acts relating to the procedure for the organization of corporations; and the various decisions of the law courts of the state of Maine bearing on these acts.

COLONIAL ORDINANCES, 1641–47.

This act, first adopted by the General Court of the Colony in 1641 and amended in 1647, reads as follows:

Liberties Common.

2. Every inhabitant who is an householder shall have free fishing and fowling in any great ponds, bayes, Coves, and Rivers so far as the Sea ebbs and flows, within the precincts of the towne where they dwell, unless the freemen of the same Towne or the General Court have otherwise appropriated them. Provided that no Towne shall appropriate to any particular person or persons, any great Pond containing more than ten acres of land, and that no man shall come on another man's propriety without their leave otherwise than as hereafter expressed. The which clearly to determine, It is Declared, That in all Creeks, Coves and other places, about and upon Salt-water, where the Sea ebbs and flows, the proprietor of the land adjoining, shall have propriety of the low-watermark where the Sea does not ebb above a hundred rods, and not more wheresoever it ebbs further. Provided that such proprietor shall not by this liberty, have power to stop or hinder the passage of boates or other vessels, in or through any Sea, Creek, or Coves, to other men's houses or lands. And for great Ponds lying in common, though within the bounds of some Towne, it shall be free for any man to fish and fowle there and may pass and repass on foot through any man's propriety for that end, so they trespass not on any man's Corn or Meadow.

A case recently decided by the Supreme Judicial Court of Maine covers in an interesting and thorough, although concise manner, the early history of the various acts of the colonial courts and legislatures upon which the law of Maine is based. (See Conant *v.* Jordan, 107 Me. 227.)

DECISIONS OF LAW.

Many decisions have been rendered by the courts on these Colonial Ordinances, among which may be noted the following:

"Although fishing and fowling are the only rights named in the ordinance, it has always been considered that its object was to set apart and devote the great ponds to public use, and that . . . these public reservations, at first set apart with reference to certain special uses only, become capable of many others which are within the designs and intent of the original appropriation. The devotion to public use is sufficiently broad to include them all, as they rise." (West Roxbury *v.* Stoddard, 7 Allen, 158. Watuppa Reservoir Co. *v.* Fall River, 147 Mass. 548, 557.)

It is a rule of law peculiar to Maine and Massachusetts under the Colonial Ordinance of 1641–47 that all great ponds — that is, ponds containing more than ten acres — are owned by the State.

While private property cannot be taken for public use without compensation, the waters of great ponds and lakes are not private property.

Under the ordinance, the state owns the ponds as public property held in trust for public uses. It has not only the *jus privatum*, the ownership of the soil, but also the *jus publicum* and the right to control and regulate the public uses to which the ponds shall be applied.

The authority of the state to control waters of great ponds and determine the uses to which they may be applied is a govermental power, and the governmental powers of the state are never lost by mere non-use. (Auburn *v.* Union Water Power Co., 90 Me. 577.)

The ordinance has been held to be broad enough to justify the state in granting authority to a certain commission to forbid the public navigating the waters of a great pond set aside as a reservoir for water supply. Defendant denied the right of the commissioners to keep him off.

Held: "There is no doubt that the control of the great ponds in the public interest is in the legislature that represents the public. It may regulate and change these public rights or take them away altogether to serve some paramount public interest. . . . The legislature having seen fit to devote the waters of the lake to a public use for the benefit of the inhabitants of the metropolitan water district, it was in its power to deprive the general public of the right to go upon it with boats or otherwise, on the ground that a safe and advantageous use of the water for drinking, and for other domestic purposes, would be best promoted by terminating this former right and putting the property in the control of the water board." (Sprague *v.* Minon, 195 Mass. 581, 583.)

The waters of great ponds being, by virtue of the ordinance, public waters, may be devoted to any legitimate public use. In the case of Watuppa Reservoir Co. *v.* Fall River, 147 Mass. 548, the city of Fall River was authorized by the legislature to draw daily one million five hundred thousand gallons of water from the North Watuppa Pond (a great pond) and to "apply the water taken under this act to all domestic uses, the extinguishment of fires, and to the public use of the city." The plaintiffs were the owners of manufacturing establishments on the only outlet of the pond and were owners also of the bed and land on either side of the stream, they were incorporated for the purpose of constructing a reservoir in the pond, and had at great expense acquired flowage rights all around the pond, built a dam, raised the water of the pond, and were maintaining their reservoir. The draw-off by the city caused actual injury to plaintiffs, who contended that the statute authorizing such withdrawal of water without compensation to plaintiffs was unconstitutional.

Held: "These are all public purposes. The legislature acting on the conviction that an abundant supply of pure water to the people is of paramount importance, has deemed it to be a wise policy to appropriate the waters of this pond to those public uses without making compensation to those who, owning land on the natural stream flowing from it, have been accustomed to use the water for power as it flows through the stream. Such owners have no vested rights in the waters of the pond, and a majority of the court is of the opinion that the Commonwealth may thus appropriate the waters by its direct action, or may authorize a city or town to do so, without being legally liable to pay any damages to the littoral owners on the pond or on the stream." (Watuppa Reservoir Co. *v.* Fall River, 147 Mass. 548.)

"They [the colonists] reserved to the Colony the property in the ponds themselves, the better to regulate these and other kindred public rights for common good." "The ordinance secures to the Commonwealth, in great ponds, the same kind of ownership in the water that an individual purchaser of the entire area of a small pond would get by a perfect deed, or by an original grant from the government without restrictions." (Minority opinion, Watuppa Reservoir Co. *v.* Fall River, 147 Mass. 548.)

In the case of the state of Maine, it is to be noticed that the exceptions in the Colonial Ordinance, namely, of ponds "otherwise appropriated" by the freemen of a town, or by the General Court, have never applied here and are not required. We know of no grants by towns, nor by any general court. Here there were no apparent limitations. Here, we feel bound to say, the doctrine of the English common law of private ownership in great ponds was never recognized nor adopted, and fowling on and fishing in them was free from the beginning. (Conant *v.* Jordan, 107 Me. 240.)

The state can at its discretion authorize the diversion of the waters of great ponds for public purposes without providing compensation to riparian owners upon the ponds or their outlets. (American Woolen Co. *v.* Kennebec Water District, 102 Me. 153.)

It is too late in the history of the question in this state to contend that the state has not the constitutional power to grant superior, or even exclusive privileges, in the use of its public rivers to persons or corporations. The state represents all rights and privileges in our fresh-water rivers and streams, and may dispose of same as it seems fit. (Mullen *v.* Penobscot Log Driving Co., 90 Me. 555.)

The extra stores of water collected by the mill owner for his use are his own. They could be taken by the state for the public for a compensation. (Pearson *v.* Rolfe, 76 Me. 389.)

The water of the great natural ponds or lakes cannot be lawfully drawn down below their natural low water line, without legislative authority; nor under the mill act.

A bill in equity may be maintained by the owner of land bounded on a great pond to restrain by injunction mill-owners on the outlet from drawing off the water in such pond below its natural low-water mark by excavating the channel or deepening the outlet. (Fernald *v.* Knox Woolen Co., 82 Me. 48.)

Lands bounded upon rivers above the ebb and flow of the tide generally extend to the middle of the stream, but lands bounded on fresh-water lakes and ponds extend only to low-water mark. (Stevens *v.* King, 76 Me. 198.)

It seems that land bounded on a natural lake or pond extends only to the water's edge; otherwise if the pond is artificial. (Robinson *v.* White, 42 Me. 209.)

In the conveyance of land bounded on a fresh water pond, which has been permanently enlarged by means of a dam at its mouth, the title extends to the low-water mark of the pond, in its enlarged state. (Wood *v.* Kelley, 30 Me. 47.)

The rule of common law, that riparian proprietors own to the thread of fresh water rivers, has been adopted in this state. (Brown *v.* Chadbourne, 31 Me. 9.)

Below the line of low water, the state owns the beds of navigable rivers and great ponds, and holds them in trust for the public in accordance with the Colonial Ordinance of 1647. (Haynes *v.* Dewitt Ice Co., 86 Me. 319.)

A navigable stream is subject to public use as a highway for the purpose of commerce and travel.

All streams of sufficient capacity in their natural condition to float boats, rafts, or logs, are deemed public highways and as such are subject to the use of the public.

Held: " That the Presque Isle stream above the bridge at Presque Isle village, for a distance of thirty miles, is a navigable stream in fact, etc., applies to passage of stream by boat or canoe." (Smart *v.* Aroostook Lumber Co., 103 Me. 37.)

The Mill Act.

This act (Rev. Stat., Chap. 94) had its origin in Massachusetts in the early part of the last century and has been continued with slight modifications both in that state and in Maine to the present time. The principles have been handed down in these two states alone, although some features of them have been adopted by neighboring states. The object of the statute, in the preamble to this law at its origin, was as follows:

> "Whereas, it has been found, by experience, that when some persons in this province have been at great cost and expenses for building of mills serviceable for the public good and benefit of the town, or considerable neighborhood in or near to which they have been erected, that in raising a suitable head of water for that service, it hath sometimes so happened that some small quantity of lands or meadows have been thereby flowed and damnified, not belonging to the owner or owners of such mill or mills, whereby several controversies and law suits have arisen, for the prevention whereof for the future. Be it therefore enacted," etc. (Ancient Charters, p. 404.)

In 1795, February 27, the legislature of Massachusetts passed an additional or amendatory act, the preamble and first section of which are as follows:

> "Whereas, the erection and support of mills to accommodate the inhabitants of the several parts of the state ought not to be discouraged by many doubts and disputes; and some special provisions are found necessary relative to the flowing of adjacent lands, and mills held by several proprietors. Therefore, be it enacted," etc.
>
> "That when any person hath already erected, or shall erect any water mill on his own land or on the land of any other person, by his consent legally obtained, and to the working of such mills it shall be found necessary to raise a suitable head of water; and in so doing any lands shall be flowed not belonging to the owner of such mill, it shall be lawful for the owner or occupant of such mill to continue the same head of water on the terms hereinafter mentioned."

This provision was incorporated into our statutes in 1821.

The intent and main features of the Mill Act in question are contained in the first four sections, which are as follows:

ERECTION OF MILLS AND DAMS, AND RIGHTS OF FLOWAGE.

Sec. 1. Any man may on his own land, erect and maintain a water mill and dams to raise water for working it, upon and across any stream, not navigable; or, for the purpose of propelling mills or machinery, may cut a canal and erect walls and embankments upon his own land, not exceeding one mile in length, and thereby divert from its natural channel the water of any stream not navigable, upon the terms and conditions, and subject to the regulations hereinafter expressed.

Sec. 2. No such dam shall be erected or canal constructed on the same stream; nor to the injury of any mill site, on which a mill or mill dam has been lawfully erected and used, unless the right to maintain a mill thereon has been lost or defeated.

Sec. 3. The height to which the water may be raised, and the length of time during which it may be kept up in each year, and the quantity of water that may be diverted by such canal, may be restricted and regulated by the verdict of a jury, or report of commissioners, as is hereinafter provided.

Sec. 4. Any person, whose lands are damaged by being flowed by a mill-dam, or by the diversion of the water by such canal, may obtain compensation for the injury by complaint to the Supreme Judicial Court in the county where any part of the lands are; but no compensation shall be awarded for damages sustained more than three years before the institution of the complaint.

Decisions of Law.

Numerous decisions of the courts of Maine on the Mill Act have been rendered from time to time, among which are the following:

Private property shall not be taken for public uses without just compensation; nor unless the public exigencies require. (Const., Art. 1, par. 21.)

The Mill Act, as it has existed in this state, pushes the power of eminent domain to the very verge of constitutional inhibition. If it were a new question, it might well be doubted whether it would not be deemed to be in conflict with that provision of the Constitution cited above. (Jordan *v.* Woodward, 40 Me. 323.)

Even the reasons for the policy which occasioned such legislation have ceased to be potential, and although from the long and uninterrupted exercise of the rights of mill-owners, under this act, it must be considered constitutional, yet, no extension of their rights over private property can be allowed by implication. (Jordan *v.* Woodward, 40 Me. 317.)

The constitution of the state, Art. 1, Sect. 21, in the Declaration of Rights, provides that " private property shall not be taken for public uses, without just compensation, nor unless the public exigencies require." And it is held to be necessarily implied that private property cannot be taken for private uses without the consent of the owner, with or without compensation.

Private property may be taken by the sovereign power of the government in the exercise of the right of eminent domain for purposes of public utility.

Interests in water, as well as in land, may be taken by virtue of this power, and both are equally the subjects of compensation. (Hamor *v.* Bar Harbor Water Co., 78 Me. 127.)

Whether a public exigency exists for the granting of the exercise of the right of eminent domain, is for the legislature to determine. Whether the use for which it is granted is a public one, the court must decide. (Brown *v.* Gerald, 100 Me. 352.)

Whether there is such an exigency, — whether it is wise and expedient or necessary that the right of eminent domain should be exercised, in case the use is public,— is solely for the determination of the legislature. The legislature however cannot make a private use public by calling it so. Whether the use for which it is granted is a public one must in the end be determined by the court. (Brown *v.* Gerald, 100 Me. 360.)

These cases relate to railroads, water companies, boom companies, canals, and the improvement of public streams. As to such cases there is now no doubt. Their uses are rightly deemed public. The public, or such part of the public as has occasion to, may directly enjoy them. Such uses are of great public benefit. (Brown *v.* Gerald, 100 Me. 361.)

We think it should be conceded that the taking of land for the purpose of supplying the public, or so much of the public as wishes it, with electric lighting, is for a public use. . . . The charter unquestionably gives the company the right of eminent domain for the purpose of supplying a current for electric lighting. (Brown *v.* Gerald, 100 Me. 356.)

Saw mills and grist mills, carding mills and fulling mills, cotton gins and other mills, which are regulated by law, and obliged to serve the public, are undoubtedly a public use. But, as respects all other kinds of mills, although they may be a public benefit, they are not a public use within the meaning of the constitution. (State *v.* Edwards, 86 Me. 102.)

Manufacturing, generating, selling, distributing, and supplying electricity for power, for manufacturing or mechanical purposes, is *not* a public use for which private property may be taken against the will of the owner.

A corporation empowered by its charter to generate and transmit electric power, for lease or sale, and having granted to it the right of eminent domain, does not by accepting the provisions of its charter become a quasi-public corporation, and does not thereby become invested with the right to exercise the eminent domain for the purpose of supplying electric power for manufacturing purposes. (Brown *v.* Gerald, 100 Me. 352.)

The legislature has the constitutional power to authorize the erection of dams upon non-tidal public streams to facilitate the driving of logs, without providing compensation for mere consequential injuries where no private property is appropriated.

Where such a dam, erected in accordance with legislative authority, causes an increased flow of water at times in the channel below, thereby widening and deepening the channel and wearing away more or less the soil of a lower riparian owner, it is not such a taking of private property as entitles the owner to compensation. It is a case of *damnum absque injuria.* (Brooks *v.* Cedar Brook & C. Imp. Co., 82 Me. 17.)

By our Mill Act., Rev. Stats., Chap. 94, any person may build upon his own land across a non-navigable stream a water-mill and dams to raise a head of water for working it, and may thereby flow back the water of the stream upon the lands above as high and as far as he deems necessary for the profitable working of his mill, subject only to the conditions and restrictions named in the act itself. The land owners must submit to the flowage, and content themselves with the pecuniary compensation to be obtained through proceedings provided by the statute. Such mill owner can also in the same way increase the height of his dam and the extent of the flowage from time to time as the exigencies of his business may seem to him to require, he making increased compensation for the increased flowage.

But there is one important and absolute exception to the above-named statutory right to retard the natural flow of a stream: " No such dam shall be erected (or canal constructed) to the injury of any mill (or canal) lawfully existing on the same stream." (Section 2 of Mill Act, Rev. Stats., Chap. 94.) It follows, as a corollary, that when a second mill has been built above the flowage of the first and older mill and dam, such flowage cannot be increased by raising the dam or by other appliances so as to lessen the original efficiency of the mill above. Whatever the greater age of his mill, the right of a mill owner to increase his head of water ceases when the flowage begins to injure the operation of a mill, however new, if already lawfully erected before the injurious flowage began. So long, however, as the additional flowage does not reach up so far as to injuriously affect some mill by that time lawfully erected, the right to increase the flowage is unlimited except as limited by the statute itself. This increase can be effected by raising the height of the solid dam, by the use of flashboards, or by other appliances. The owners of *unoccupied* water powers, or mill sites, must submit to have them flowed out and made useless, and must content themselves with the statutory compensation. (National Fibre Board Co. *v.* L. & A. Electric Co., 95 Me. 321.)

The plaintiff whose land has been overflowed by a *reservoir dam* erected by the defendants upon their own land, but for the use of a mill not owned by them nor standing upon their land, may maintain an action on the case for the damages caused by such dam. The process by complaint, under Rev. Stats. 94 (Mill Act), cannot be sustained upon these facts. (Crockett *v.* Millett, 65 Me. 191.)

As between proprietors of dams on the same stream, he has the better right who was first in point of time.

Unless the plaintiff abandoned his site, the temporary destruction of his dam would not enable the defendant to acquire, as against the plaintiff, the right of a prior occupant. (Lincoln *v.* Chadbourne, 56 Me. 197.)

Mill owners have a right to maintain their dam as it was at the time of the deeds to them; and if, through want of repair for a series of years subsequent to that, it lets the water escape, the owners have the right to repair and tighten it, although the water is thereby raised higher and retained longer than it was while the dam was in a dilapidated condition. (Butler *v.* Huse, 63 Me. 447.)

NATURAL FLOW.

Thurber *v.* Martin, 2 Gray, 394, was an action of tort for obstructing the natural flow of the water, and diverting it from the plaintiff's mill. In delivering the opinion of the Court, Chief Justice Shaw thus stated the law of the case:

> " Every man has the right to the reasonable use and enjoyment of a current of running water, as it flows through or along his own land for mill purposes, having a due regard to the like reasonable use of the stream by all the proprietors above and below him. In determining what is such reasonable use, a just regard must be had to the force and magnitude of the current, its height and velocity, the state of improvement in the country in regard to mills and machinery, and the use of water as a propelling power, the general usage of the country in similar cases, and all other circumstances bearing upon the question of fitness and propriety in the use of the water in the particular case." (Davis *v.* Winslow, 51 Me. 292.)

Every proprietor of land on the banks of a river or stream has naturally an equal right to the use of the water; and this right to use implies a right to control, detain, and even diminish the volume of the water, — but only to a reasonable extent.

What is a reasonable detention depends upon the size of the stream, as well as upon the uses to which it is subservient, as the detention must necessarily be sufficient to accumulate the head of water requisite for practical use.

The right of detention is not limited to time necessary for repairs or to extraordinary occasions, but applies to the ordinary use of such streams, provided it be not an unreasonable use or detention. (Davis *v.* Getchell, 50 Me. 602.)

Thus he may apply it to domestic purposes or purposes of irrigation, but not to such an extent as unreasonably to diminish its quantity. (Davis *v.* Getchell, 50 Me. 604.)

In Pitts *v.* The Lancaster Mills, 13 Metcalf, 157, the defendants, owners of a mill and dam above an ancient mill dam of the plaintiffs, rebuilt and raised that dam above its former height, whereby the water was wholly cut off from the plaintiff's mill for a period of six days, greatly to his detriment. The case was submitted to the Court upon an agreed statement of facts, and a non-suit was ordered, the Court assigning as a reason therefor, that " this was not an unreasonable use of the watercourse by the defendants, and that any loss which the plaintiffs temporarily sustained by it was *damnum absque injuria.*" (Davis *v.* Winslow, 51 Me. 292.)

A mill owner has no right to unnecessarily and unreasonably detain water from those who have a right to use it subsequent to his own; and he will be liable in damages for doing so.

What is a reasonable use and what an unreasonable detention, are questions of fact for the jury. (Phillips *v.* Sherman, 64 Me. 171.)

The new dam raised the outlet some three feet, and held the water at that level, but did not divert it. No more water was thereby taken from the stream than the capacity of the 24-in. pipe would divert. That quantity might be taken, even if no water should be left to flow in the natural channel. The natural flow was substantially the same with the new dam as with the old or without any dam. (Hamor *v.* Bar Harbor Water Co., 92 Me. 364, 377.)

In the case of Mullen *v.* Penobscot Log Driving Co., 90 Me. 555, the defendant was a company chartered by the legislature for driving all logs of all owners in the West Branch waters, and the company was given the exclusive control and management of the waters of the river, so far as necessary to enable it to successfully execute the obligations resting upon it, an obligation in some respects partaking of the character of a public trust.

Held: the plaintiff was not entitled even to the natural flow or to draw from the reserves of water in order to create what would at the time and place be equivalent to the natural flow, so long as the company needed or would be likely to need the same water for driving its own logs to market. The defendant's right was the superior right. The plaintiff's right was secondary and conditional. Such is the inevitable effect of the grants to the company by the legislature. The stores of water are accumulated by using the natural flow until the necessary head is obtained. It was not that the defendant company would not let the water down when it needed its use itself, but the plaintiff desired the use and advantages of it in advance of the use of it by the company.

FLOATABLE STREAMS.

A stream which, in its natural condition, is capable of being commonly and generally useful for floating boats, rafts or logs, for any useful purpose of agriculture or trade, though it be private property, and though it be not strictly navigable, is subject to the public use, as a passageway.

Though the adaptation of the stream to such use may not be continuous at all seasons, and in all its conditions, yet the public right attaches, and may be exercised whenever opportunities occur.

When a stream is inherently, and in its nature, capable of being used for the purpose of commerce, for the floating of vessels, boats, rafts, or logs, the public easement exists.

In such a stream, the right in the public exists, notwithstanding it may be necessary for persons floating logs thereon to use its banks. (Brown *v.* Chadbourne, 31 Me. 9.)

In order to make a stream floatable it is not necessary that it should be so at all seasons of the year. It is sufficient if it have that character at different periods with reasonable certainty and for such a length of time as to make it profitable for that purpose.

The question is whether the stream is floatable without the dam. If it is not, the plaintiff could not avail himself of the fact that it is made so by the defendant's dam. If the stream was originally private property, exclusively so, any improvements made upon it by the owner would give the public no rights on it. But if on the other hand the stream is by nature floatable, those who have occasion to use it as such may do so and may also have the benefit of such improvements as may be put upon it having reasonable regard to the rights of the owner. (Holden *v.* Robinson Co., 65 Me. 216, 217.)

The judge instructed the jury that if the river in its natural state was capable of being useful for floating boats, logs, etc., for purposes of trade or agriculture, the plaintiff was entitled to recover, however long the dam of the defendant might have stood; and notwithstanding his use of the river had been open, notorious, and adverse, and although no logs had ever been floated over the falls where the dam now is. (Knox *v.* Chaloner, 42 Me. 150.)

Whether a stream is capable of being used as a passageway for the purposes of commerce is a question of fact for the jury. (Treat *v.* Lord, 42 Me. 552.)

The presiding judge instructed the jury that if Cold Stream was such a stream as the public would have an easement in for the driving of logs, on account of its inherent capacity for being so used . . . that the right of way was in the waters, and the plaintiff in such case would have no authority to prevent its exercises; that he could by law erect and continue his dams and mills, but was bound to provide a way of passage for the defendants' logs; that some streams are entirely private property, and some are subject to the public use and enjoyment; that the test has been sometimes held to consist in the fact whether they are susceptible or not of use as a common passageway for the public. And, by request of plaintiffs' counsel, the judge instructed the jury " that if the stream was incapable in its natural state of being used to propel logs without the erection of dams or other structures on plaintiffs' land, there could be no public servitude."

The judge also instructed the jury that the law, as established in this state, and which they would take for their guide, was, that " the true test to be applied in such cases is whether or not a stream is inherently and in its nature capable of being used for the purposes of commerce, for the floating of vessels, boats, rafts, or logs — when a stream possesses such a character, then the easement exists, leaving to the owners all other modes of use not inconsistent with it"; that a stream might possess such a character, even though, when the forest was first opened on its shores, it were so obstructed by fallen trees, brush and driftwood, that neither vessels, boats, rafts, or logs could be floated, through its course, upon its surface, until such obstructions had been removed; that, perhaps, many such streams, when the forests about them were first opened, would need such clearing out before they could be profitably used; and that it was a question for the jury to determine, from the evidence in the case, whether or not the stream was inherently and in its nature capable of being used for the purposes of commerce, for the floating of vessels, boats, rafts, or logs. (Treat *v.* Lord, 42 Me. 555, 556.)

The controversy in the case of Pearson *v.* Rolfe, 76 Me. 380, arose from a conflict between log-owners and mill-owners as to their respective rights in the use of the water at certain falls in the Penobscot River in the town of Old Town. Pearson represents mill-owners, Rolfe represents log-owners. Pearson has mill structures upon his privilege, with such appendages as dams, sluices, and booms. Rolfe had a quantity of logs in the river which he was unable to drive over the dam at Pearson's mills, *unless Pearson would shut down his mill-gates,* thereby suspending his own business of manufacturing, until water enough should accumulate in his mill-pond to float the logs over. This Pearson refused to do, basing his refusal upon the allegation that the driftway in the dam, without shutting down his working gates, afforded all the facility for floating logs by his mills that existed in the river at that place in its natural state, — as much as there would be, provided his mills and all of his structures were entirely out of the way. Rolfe contends that the facts were otherwise, but further contends that Pearson, even if he represents the facts truly, having it within his power to furnish more water than the natural facility and flow, was under an obligation from his situation to do so.

The counsel for Rolfe contended that the doctrine of *reasonable use* applied; and that, if the river in its natural condition would not furnish a sufficient flow, Rolfe was entitled to the use of the river in its changed condition for his purposes. We think this position cannot be maintained. Our idea is that the doctrine of reasonable use does not apply when the river is *not* naturally floatable; but does apply when it *is* naturally floatable or log-navigable, when both parties can use the natural flow and desire to use it at the same time. We are well satisfied that, whenever logs cannot be driven over a particular portion of a fresh water river such as the Penobscot, above the flow and ebb of the tide, while in its natural condition, such portion of the river is not at such time navigable or floatable, and that the use of the water at such time, and place, belongs exclusively to the riparian proprietor, so far as he needs the same for his own purposes.

The Penobscot River at the place in question, as before intimated, was floatable only, — floatable, because capable of valuable use in bearing the products of the forests to markets or mills. A floatable stream is the least important of the classes of streams called navigable. Rolfe had the right to use the river so far as it was a floatable river, in such parts or places and at such times as it was floatable. He had the right to avail himself of its navigable capacity for floating logs. But only so far as it was navigable or floatable in its *natural condition.* It is the natural condition of a stream which determines its character for public use, and it must be its navigable properties in a natural condition unaided by artificial means or devices. It is well settled in this state and elsewhere, that, if a stream is not susceptible of valuable use to the public for floatable purposes, without erections for raising a head, it cannot legally be deemed a public stream, even though it might be easily converted into a floatable stream by artificial contrivances. Wadsworth *v.* Smith, 11 Me. 278; Brown *v.* Chadbourne, 31 Me. 9; Treat *v.* Lord, 42 Me. 552; Nuis. (2d. ed.), 463, and cases.

The log driver takes the waters as they run, and the bed over which they flow as nature provides. Nor has any person the right, unless upon his own land, or under legislative grant, to remove natural obstructions from the bed of a river in order to improve its navigation. This is clear from the same authorities.

On the other hand, what rights have the adjudged cases accorded to the riparian proprietor in merely floatable and non-tidal streams? It is settled in this state that he owns the bed of the river to the middle of the stream. He owns all the rocks and natural barriers in it. He owns all but the public right of passage. The right of passage does not include any right to meddle with the rocks or soil in the bed of the river. If rocks are taken, the owner may sue in trespass for the act, or may replevy them from the wrongdoer. (Pearson *v.* Rolfe, 76 Me. 383–386.)

Let it be borne in mind that the complaint against Pearson is not that he kept back the natural flow, but that he refused to keep it back, — that he would not shut down his gates and suspend his business in order to keep it back. The demand was that he should suspend his own sawing and shut down his mill-gates until the accumulation of water in the mill pond might be enough to create a navigable flow through the public passage. (*Supra*, p. 387.)

Held: A mill-owner upon a floatable river is not under legal obligation to provide a public way, for the passage of logs over his dam, better than would be afforded by the natural condition of the river unobstructed by his mills. The right of passage is to the natural flow of the river or its equivalent.

Held: A mill-owner is not under legal obligation to furnish any public passage for logs over his dam or through his mills at a time when the river at such place, in its natural condition, does not contain water enough to be floatable if unobstructed by mills, although the river is generally of a floatable character.

Held: Whenever a river, with mills upon it, is floatable, and the mill-owner and those who want to float logs past the mills are desirous of using the water at the same time, all parties are entitled to reasonable use of the common boom; the right of passage is the superior, but not an usurping, excessive, or exclusive, right; the law authorizing mills puts some incumbrance upon the right of passage. (*Supra*, p. 380.)

The reasonableness of the use depends upon the nature and size of the stream, the business or purpose to which it is made subservient, and on the ever-varying circumstances of each particular case. Each case must stand upon its own facts, and can be a guide in other cases only as it may illustrate the application of general principles. (*Supra*, p. 390.)

MEASUREMENT OF WATER-POWER.

Grants and reservations relating to water and water-power are various in their nature and effect. Some refer to a certain extent of water-power sufficient for the propulsion of a specific mill or machinery: Warner *v.* Cushman, 82 Me. 168; Hammond *v.* Woodman, 41 Me. 177; Covel *v.* Hart, 56 Me. 518, 522; Elliott *v.* Sheperd, 25 Me. 371; Ashley *v.* Pease, 18 Pickering, 268. Some to a quantity of water to be restricted to a specific purpose: Deshon *v.* Porter, 38 Me. 293. Others to "such quantity of water as the grantor or his predecessor have been accustomed to use": Avon Man'f'g Co. *v.* Andrews, 30 Conn. 476. Still others, to such quantity of water as will flow through a gate of specific dimensions under a specific head of water: Bardwell *v.* Ames, 22 Pickering, 333; Tourtellot *v.* Phelps, 4 Gray, 373. Head is a well-known material factor in determining the quantity of water which will pass through a given aperture in a given time. Canal Co. *v.* Hill, 15 Wallace, 94, 102. (Gray *v.* Saco Water Power Co., 85 Me. 528.)

The United States Supreme Court has held as follows:

A grant of a right to draw from a canal so much water as will pass through an aperture of given size and given position in the side of the canal is substantially a grant of a right to take a certain quantity of water in bulk or weight. What that quantity is may be ascertained from the character and depth of the canal, the circumstances under which the water is to be drawn, and the state of things existing at the time the grant is made.

The grantee will be entitled to draw this quantity even though it may be necessary to have the aperture enlarged if it can be done without injury to the grantor. (Canal Co. *v.* Hill, 15 Wallace, 94.)

Where a grantor, owning all the water-power on both sides of a stream, conveyed the saw mill thereon, "with the right of use of all water not necessary in driving the wheel, or its equal, now used to carry the machinery in the shingle mill, — meaning to convey a right to all the surplus of water not required for the shingle mill or other equal machinery," — and it appeared that, at the time of the conveyance, the shingle mill contained various other machinery besides the shingle machine:

Held, that the parties thereby fixed the measure of the water not conveyed, and that its use was not confined to the specific purpose of driving the shingle machine.

Held, ~~also,~~ that the owner of the shingle mill might lawfully put into it a board saw, and use the same, provided the wheel used for propelling it consumed no more water than was previously used, even if the owner of the saw mill thereby lost all his patrons. (Warner *v.* Cushman, 82 Me. 168.)

A reservation of water necessary and sufficient to carry two run of mill stones.

Held, a reservation of a quantity sufficient for the purpose with the machinery in actual or contemplated use at the mill at the time the reservation was made, and not restricted then or afterwards to such quantity as with improved machinery and facilities would perform the same work.

Held, also, to reserve an absolute right to the use of the quantity of water named; and to be a reservation of a fixed measure of power to be used for any purpose, and not confined to the grist mill. (Blake *v.* Madigan, 65 Me. 522.)

A grant by the owner of a dam of the right to use five hundred square inches of water, for the purpose of creating power, as a substitute for a prior grant, in which the head was not mentioned, carried by implication the right to draw the water from the dam, at the head of which water was ordinarily taken under the prior grant. (Oakland Woolen Co. *v.* Union Gas & Electric Co., 101 Me. 199.)

The Franklin Company, the then owner of a dam lawfully maintained across the Androscoggin River at Lewiston for raising a head of water for generating power, granted by an instrument of indenture to the City of Lewiston the right to draw from its dam "water to the extent of 600 horse-power for the purpose of pumping," etc. (the head of water being fixed at not less than 25 ft. nor more than 30 ft.). After full consideration of the subject matter of the grant, the situation, the history and character of the negotiations, and all the language used by the parties in the instrument finally signed by them as defining their rights and obligations, thereunder, *held:*

a. The grant is not of water-power, but only of water for power, and the city is entitled, not to a certain quantity of power, but only to draw a certain fixed quantity of water from which to extract as much power as it may by its own agents and appliances.

b. From the evidence and the admissions of the plaintiff it appears that the phrase "to the extent of 600 horse-power" means in its connection, efficient, practical horse-power upon a well-understood and recognized basis of seventy-five per cent. of efficiency, and hence the city is entitled to draw for pumping purposes water to the extent of 800 nominal or theoretical horse-power and no more. (Union Water Power Co. *v.* Lewiston, 101 Me. 565.)

Some time in the 80's an interesting case was tried in one of the Maine lower courts, known as the "Brunswick Water Case." Mr. J. Herbert Shedd testified as to the value of a "saw," a term used in the early days to designate the horse-power required to operate the old undershot and flutter wheels used in the saw mills on the Androscoggin River at Brunswick. His results, based on several different methods of computations, gave one "saw" equal to 120 nominal horse-power, or, "that about 120 horse-power of water might be taken to be the measure of water which was used anciently to run one saw." This was not effective horse-power based on the efficiency of the wheels, but theoretical, based on the discharge and head. He stated that the old flutter wheels had an efficiency of from one sixth to one eighth of the total power, and that the actual power to run an old-fashioned saw was about 15 to 20 horse-power.

IMPROVEMENT OF MARSHES, MEADOWS, AND SWAMPS.

The provisions of Revised Statutes entitled, "Improvement of Marshes, Meadows, and Swamps" (Chap. 26, Sec. 42–70), are important as bearing on developments of water courses in this state although of somewhat lesser importance than the Mill Act previously described. The first five sections read as follows:

Sec. 42. When any meadow, swamp, marsh, beach, or other low land is held by several proprietors, and it becomes necessary or useful to drain or flow the same, or to remove obstructions in rivers or streams leading therefrom, such improvements may be effected under the direction of commissioners in the manner hereinafter provided.

Sec. 43. Such proprietors, or a majority of them in interest, may apply by petition to the Supreme Judicial Court sitting in the county where the lands or any part of them lie, setting forth the proposed improvements and the reasons therefor, and the court shall cause notice of the petition to be given in such manner as it may judge proper, to any proprietors who have not joined in the petition, that they may appear and answer thereto.

Sec. 44. If upon hearing, it appears that the proposed improvements will be for the general advantage of the proprietors, the court may appoint three suitable persons as commissioners, who shall be sworn to the faithful discharge of their duties; view the premises, notify parties concerned, hear them as to the best manner of making the improvements, and prescribe the measures to be adopted for that purpose.

Sec. 45. They shall, according to the tenor of the petition and order of court, cause dams or dikes to be erected on the premises, at such places and in such manner as they direct; may order the land to be flowed thereby for such periods of each year as they deem most beneficial; and cause ditches to be opened on the premises, and obstructions in any rivers or streams leading therefrom to be removed; and they shall meet from time to time, as may be necessary, to cause the works to be completed according to their directions.

Sec. 46. They may employ suitable persons to erect the dams or dikes, or to perform the other work, under their direction, for such reasonable wages as they may agree upon; unless the proprietors do the same in such time and manner as the commissioners direct.

ORGANIZATION OF CORPORATIONS.

The procedure for the organization of corporations in this state is in accordance with the provisions of law as follows: Rev. Stats., Chap. 47; Pub. Laws, 1903, Chap. 235; Pub. Laws, 1905, Chaps. 85, 162, 171, 172; Pub. Laws, 1907, Chaps. 16, 71, 86, 109, 154, 172, 185.

Section 2 of Chapter 47 of the Revised Statutes has an important bearing on what follows regarding proposed legislation for the creation of drainage districts, and the state supervision of the construction of dams and control of reservoirs. The section in question is as follows:

Acts of incorporation, passed since March seventeen, eighteen hundred and thirty-one, may be amended, altered or repealed by the legislature, as if express provision therefor were made in

them, unless they contain an express limitation; but this section shall not deprive the courts of any power which they have at common law over a corporation or its officers.

PRESENT STATE SUPERVISION OF DAMS.

Section 43 of the Mill Act (Rev. Stats., 94) provides as follows:

> The governor, with the advice and consent of the council, shall annually appoint a competent and practical engineer, a citizen of the state, who shall hold said office until his successor is appointed and qualified, and who shall upon petition of ten resident taxpayers of any town or several towns, the selectmen or assessors of any town, or the county commissioners of any county, inspect any dam or reservoir located in such town or county, erected for the saving of water for manufacturing or other uses, and after personal examination and hearing the testimony of witnesses summoned for the purpose, he shall forthwith report to the governor his opinion of the safety and sufficiency thereof.

The paragraph above quoted was adopted in 1875. The next section provides that, in case the dam is reported as unsafe, the owners shall immediately repair same and in default thereof may be enjoined from the use of the dam, and the waters behind the dam may be discharged therefrom. When the dam is reported as safe the expenses of inspection shall be paid by the state, and when adjudged unsafe and insufficient, by the owner or occupant of the dam.

Since 1883 to the present time, nine separate accounts, totaling $260.57, have been paid by the state under the above provisions of law, and it is safe to assume that a less number of inspections, if any, have entered the decree of unsafe and insufficient.

The act creating the State Water Storage Commission was passed in 1909, Section 4 providing as follows:

> Every person, firm or corporation before commencing the erection of a dam for the purpose of developing any water-power in this state, or the creation or improvement of a water-storage basin or reservoir for the purpose of controlling the waters of any of the lakes or rivers of the state, shall file with said commission for its information and use copies of plans for the construction of any such dam or storage basin or reservoir and a statement giving the location, height and nature of the proposed dam and

appurtenant structures, and the estimated power to be developed thereby, and in case a dam is to be constructed solely for the purpose of water storage and not for the development of a water power at its site, plans and statements shall be filed with the commission showing the extent of the land to be flowed, the estimated number of cubic feet of water that may be stored and the estimated effect upon the flow of the stream or streams to be affected thereby. Every person, firm or corporation shall, as soon as practicable, after this act takes effect, file similar plans, reports and estimates in relation to any dam or storage basin or reservoir then in the process of construction by them.

There are no mandatory provisions compelling the filing of plans, and there is absolutely no mention of a state examination of the sufficiency of the design or provision for inspection during construction.

PROPOSED LEGISLATION.

From the confusion of a year or so ago, regarding the relationship of the public to quasi-public service companies and corporations, a method of procedure is slowly being evolved in the various states. It is largely taking the form of the appointment of public utilities commissions or of commissions with similar standings where, through their powers conferred upon them by legislative acts, the public have an intimate control of the affairs of corporations.

It is believed that some kind of control of Maine's water-powers and storage basins should be exercised by the state. Development of our water-powers is progressing, and the state should encourage every effort in this direction, but not to the detriment of its present or future interests. Concentration of water-power control and mergers of various companies have taken place during the past year in this state, and it is believed that public regulation is necessary. The entire subject is at present in a formative stage, and methods of procedure, policies, and ideas have not yet thoroughly crystallized. It is a matter for discussion and consideration by many minds.

A bill, introduced late in the session of the last legislature, 1911, having the approval of the chief engineer, provided for state regulation of water-power and water-storage companies. Provision was made for enlarging the powers of the State Water Storage Commission and placing the operations of the act under its direction. The measure in question was something entirely new in so far as this state was concerned, but it contained nothing that had not been adopted by one or the other of several states, including New York, Wisconsin, Pennsylvania, and Oregon. At the time given for the hearing of the bill before the legal affairs committee of the legislature, nearly all of the large water-power interests of the state were represented. The proponent of the measure realized that it was late in the session for adequate consideration of the various features of the bill and he therefore suggested to the committee that the bill be referred to the next legislature, which was done.

There is given below the text of the bill proposed by the chief engineer. It is somewhat modified from the proposed act that was referred to the 1913 legislature. The main intent of many of the features of the bill is to place the operations of water-storage and power-companies under an engineering commission. Many difficulties that now come before the legislative committees should be obviated through its operation. The following is a brief discussion of the various sections.

Section 1 empowers the State Water Storage Commission to divide the state into drainage districts by watershed lines for the purpose of creating administrative districts in order to carry out the provisions of the act.

The purpose is stated to be the state control and regulation of all great ponds of the state and all reservoirs created or hereafter created in part or in whole on any state lands or public lots. The section further authorizes the commission to mark, by permanent monuments, heights to which water may be raised or lowered on the reservoirs of the state, and further authorizes the commission to supervise the time and extent of the drawing of water from such reservoirs. Some such control is deemed necessary on account of the advantages that are given to various reservoir companies by later provisions of the act, especially Section 16, given below.

Exceptions have been taken to this latter provision as impairing existing contracts that the state has made with various water-storage companies through charters granted in the past. It is believed that these objections cannot stand in the light of quotations given above; that is, the decision of the Supreme Judicial Court that the state owns great ponds and that the state has not lost the authority to control the waters of such great ponds; and the declaration of the Revised Statutes of Maine that all charters granted since 1831 may be amended, altered or repealed, by the legislature.

Section 1 places a restriction on the state commission by requiring it to regulate reservoirs under its control so that all water users shall derive the greatest benefit.

The section further provides that an appeal may be had from the decisions of the commission to a board of arbitration to consist of three hydraulic engineers to be appointed by a judge of the Supreme Judicial Court. The term "reservoir," as used in the bill, is defined as any storage basin having an available capacity of over 200 000 000 cu. ft. This provision was inserted in order that the state commission would be relieved of the operations of small reservoirs, especially those created by mill dams on the various rivers of the state. The 200 000 000 cu. ft. capacity is simply an arbitrary figure and might be changed if deemed advisable. This limiting capacity does not apply to reservoirs created on great ponds, as it is believed that the state should control all reservoirs on all the great ponds of the state.

Section 2 defines the term "concession" within the meaning of this act.

Section 3 declares what a public utility is within the meaning of the act.

Section 4 of the bill provides that the drainage districts created shall be in charge of district superintendents appointed by the commission through recommendation of the various water users of the district in question. This provides for the appointment of men intimately familiar with the basin, by the water users in that basin. The intent of this feature of the act is, that in case any of the water users are not satisfied with the acts of the district superintendents, appeal may be had to the state commission.

Section 5 provides that any engineers of, or members of, the state commission shall have free access to the buildings and grounds of water storage companies, shall have access to books, accounts, and plans of such companies as are necessary for the purposes of the act.

Section 6 is an important section, giving authority to the state commission to pass upon and accept or reject any plan for dams constructed in the state.

The rejection of the plans is to be only on the grounds of the inadequacy of engineering features, and in this connection a board of arbitration is furthermore provided for. The grounds for this section are on account of public safety and of publicity. Up to the present time the state of Maine has not felt the need of suitable engineering supervision of plans for storage or power dams. The time has now arrived, however, when such supervision should be had on account of the construction of larger and higher structures of this nature.

Section 7 provides that certificates of incorporation of water-storage or water-power companies shall first be filed with the State Water Storage Commission before they are approved by the attorney-general. It further provides that such certificates shall designate the body of water that is proposed to be dammed.

Section 8 has a similar object in view as the preceding section, namely, that of publicity, in that no sale, assignment, etc., of any franchise of any corporation formed for the development of storage or water-power shall be valid until it has been filed with the Water Storage Commission.

Section 9 provides that the state of Maine may at any time in the future take over the physical properties of any corporations hereafter organized for the development of water storage in the state. This is the usual provision now inserted in legislative charters for large water storage or power companies.

Section 10 provides that time limit for all concessions granted under terms of this act shall be from twenty-five to sixty years, the period of termination being determined by the State Water Storage Commission at the time of the approval of the concession. Provision is also made for possible extension of the charter.

Section 11 provides for an annual tax on the gross receipts of all water-power companies. The first draft of this section contemplated an annual tax or rental based on the horse-power developed, with provision for deduction on account of transmission losses. However, there is an objection to this method in that the man that sells his power at a lower rate is taxed higher than one who sells his power at a higher rate. To overcome this inequality the tax is to be assessed on a percentage of the gross receipts. Provision is made for the tax being assessed on a sliding scale.

Section 12 provides a penalty for non-payment of taxes.

Section 13 requires the keeping of such accounts and records as the commission deems necessary.

Section 14 provides that whenever the owner of any dam desires to take or overflow any land, he shall apply to the commission for the approval of his request, and whenever said approval is given, right of eminent domain may be exercised under the so-called mill act.

Section 15 provides that whenever the owner of any concession that has received the approval of the State Water Storage Commission desires to overflow any great pond or any public lots or state lands, application shall be made to the Water Storage Commission. The said commission is then to make an engineering investigation of the matter and report to the next legislature results of its investigations, together with its recommendations.

Section 16 provides for the reimbursement to persons or companies who make expenditures in the creation or improvement of storage reservoirs. Such owners shall be paid by the state of Maine all reasonable costs of operation and maintenance and a net annual return for twenty years of five per cent. of the cash spent in creating, improving, or increasing storage. Furthermore, all water users below, who are benefited by such increase, shall pay their proportionate share of the cost of operation and maintenance of the reservoirs and their proportional amount of the net annual return for twenty years of five per cent. of the money invested. In other words, if a person or company goes to the expense of creating, increasing, or improving storage, they are reimbursed by all the water users on the stream benefited thereby.

Section 17 provides for the installation of suitable and accurate meters and other instruments adequate for the measurement of electrical energy generated by any person, firm, or corporation in the state, and also provides for a penalty in case such meters are not installed within a prescribed limit of time. The commission is given power, however, to extend the time in which the installation must be made before the penalty attaches.

A circular letter was sent to the various light and power companies in the state, requesting them to report, among other matters, the total annual output of the generators in kilowatt hours. Answers to this question were meager, and in many cases where figures were given they were estimated. This is generally due to the fact that many companies, especially smaller ones, have no measuring devices for recording the total annual output in kilowatt hours of generating stations. It will not be many years before a Public Utilities Commission is created by statute in this state, and answers to the questions on the form will be required by that commission.

Section 18 provides for an appeal to the Supreme Judicial Court against any decisions of the State Water Storage Commission.

Drainage District Act.

The bill in question is as follows:

An Act for the creation of drainage districts, the supervision of the construction of dams, and the control and regulation of storage reservoirs.

Be it enacted by the People of the State of Maine, as follows:

Section 1. The State Water Storage Commission is hereby authorized and empowered to divide the state into drainage districts by watershed lines for the purpose of controlling and regulating all great ponds of the state and all reservoirs created or hereafter created in part or in whole on any state lands or public lots of the state; and said commission is hereby authorized and empowered to mark by permanent monuments and bench marks the heights to which water may be raised or lowered on the great ponds of the state and on all reservoirs created or hereafter created on any state lands or public lots of the state; and, furthermore, the said commission is hereby authorized and empowered to supervise and control the times and extent of the drawing of water from all great ponds and from the reservoirs created or hereafter created on any state lands or public lots of the state.

All reservoirs under the supervision and control of the State Water Storage Commission shall be regulated by said commission so that all the water users shall derive the greatest benefit.

Provided, however, that if any water user feels himself aggrieved as to the manner of said regulation, he may appeal to a board of arbitration to consist of three hydraulic engineers to be appointed by a judge of the Supreme Judicial Court, the cost of said arbitration to be paid by the party requesting the arbitration.

The term reservoir, as used in this section, shall mean any storage basin having an available capacity of over 200 000 000 cubic feet, provided, however, that this limiting capacity shall not apply to any reservoir created on any great pond of the state.

Section 2. The term "concession" as used in this act shall mean and embrace every certificate issued by the state through the State Water Storage Commission in its approval of any plans and statements filed with it in accordance with the provisions of section 6 of this act, or of every certificate issued by the said commission as provided for in sections 7, 8, and 14 of this act.

Section 3. Every person, firm, or corporation, their heirs, executors, administrators, successors, assigns, lessees, trustees, or receivers appointed by any court whatsoever, who accepts, takes and holds a concession for the erection and operation of a water storage reservoir under the provisions of this act, is hereby declared a public utility.

Section 4. The drainage districts created under the provisions of section one of this act shall be in charge of district superintendents who shall report to and receive their instructions from the chief engineer of the State Water Storage Commission. Said district superintendents shall be appointed by the State Water Storage Commission from lists of persons recommended by the water users, including the log-driving associations, the water power users and the dam and reservoir owners of the respective drainage districts. Provided, that one district superintendent may have charge of more than one drainage district.

Section 5. For the purpose of carrying out the provisions of this act, or for any other lawful purpose, the State Water Storage Commission, the chief engineer, or any other engineer, or other person appointed by said commission for that purpose, shall have free access to all parts of the buildings, structures or grounds utilized by the owner or owners of any concession granted under the terms of this act, and may take any measurements and observations, and may have access to and copy from, all books, accounts, plans and records of said owner or owners, as are necessary for the purposes of this act.

Section 6. Every person, firm, or corporation, before commencing the erection of a dam, or the enlargement of any existing dam, for the purpose of developing any water power in this state, or the creation or improvement of a water storage basin or reservoir for the purpose of controlling the waters of any of the great ponds or rivers of the state, shall file with the State Water Storage

Commission for its information and use, copies of plans for the construction of any such dam or storage basin or reservoir, and a statement giving the location, height and nature of the proposed dam and appurtenant structures and the estimated power to be developed thereby and also the name of the river, stream, lake, pond, or other body of water from which it is proposed to use water power, or on which it is proposed to store water, and as near as may be, the points on said river, stream, lake, pond, or other body of water, between which said water power or storage of water is proposed to be taken or used or developed, and such other information as said commission may require, and until said plans and statements are filed with and have received the approval of a majority of the members of said commission, and until a certificate to this effect has been issued, and the concession granted, it shall be unlawful to start construction on any such said dam or dams or appurtenant structures; and, furthermore, it shall be unlawful to change or modify any such plans or any designs until the changes and modifications have received the approval of a majority of the members of said commission, and until a certificate to this effect has been issued and the concession granted; provided, however, that the rejection of any plan or plans shall be on the ground of the inadequacy of the engineering features of the plans, unless a great pond or state land or public lot or lots are involved; and provided, further, that in case of the rejection of plan or plans on account of inadequacy of the engineering features, recourse may be had to a board of arbitration as provided for in section one. Every person, firm, or corporation shall, as soon as practicable, after this act takes effect, file similar plans, reports and estimates in relation to any dam or storage basin or reservoir then in process of construction by them.

Section 7. No certificate of incorporation, among the purposes of which are the development of water storage or water power in this state, shall be approved by the attorney-general unless said certificate is first filed with the State Water Storage Commission; nor unless said certificate of incorporation shall contain, in addition to the statements now required to be made, the name of the river, stream, lake, pond, or other body of water from which it is proposed to use water power, or on which it is proposed to store water, and, as near as may be, the points on said river, stream, lake, pond, or other body of water, between which said water power or storage of water is proposed to be taken or used or developed, and such other information as said commission may require; nor until a certificate to this effect has been issued by the State Water Storage Commission and the concession granted.

Section 8. No sale, assignment, disposition, transfer, or conveyance of the franchises, and all the property, real, personal, and mixed, of any person or firm engaged in the development of water storage or water power in this state, or of any corporation heretofore or hereafter formed, for the development of water storage or water power in this state, to any other such corporation or to any person or firm, shall be valid until a certificate, prepared and duly executed by the president and secretary of the corporation so purchasing, under the seal of said corporation, or by such person or firm designating the river, stream, lake, pond, or other body of water, and as near as may be, the points on the said river, stream, lake, pond, or other body of water, between which said water power or storage of water is proposed to be taken, or used, or developed, and such other information as the State Water Storage Commission may require, has been filed with the said commission; nor until a certificate to this effect has been issued by the State Water Storage Commission and the concession granted.

Section 9. All the property, rights, and franchises within the state of Maine acquired, erected, owned, held or controlled by any corporation, hereafter organized for the development of water storage in this state, or its successors or assigns, at any time after this act shall take effect, under and by virtue of the terms thereof, shall be subject to be taken over by, and become the property of the state of Maine, whenever said state shall determine by appropriate legislation that the public interests require the same to be done. Upon the taking effect of such legislation, the ownership of said property, rights, and franchises shall immediately be transferred to, and vested in, said state of Maine, and said state shall pay to the owner or owners thereof, the fair value of all the same, excepting, however, such franchises and rights as are conferred upon any said corporations under and by virtue of the provisions of any legislative act or acts or any special charter or charters owned or controlled by any said corporations, which said franchises and rights shall be wholly excluded in the determination of the amount to be paid to any said corporations by said state of Maine. Provided, that should the state proceed under this section, it shall assume the contracts of the company or companies whose property it takes.

The fair value of the property, rights, and franchises so taken by the state of Maine, subject to the exceptions hereinbefore mentioned, shall be determined by agreement between any said corporations and such officers and agents of said state as shall be thereunto authorized to act in its behalf by the act which authorizes the taking of said property, rights, and franchises; and such agreement failing within six months after said act takes effect, then by such fair and impartial tribunal and under such provisions as to the manner of procedure and for full hearing of parties and payment of damages awarded as shall be provided in said act.

Section 10. Any concession granted under the terms of this act shall terminate within a period of from twenty-five to sixty years from the date of approval of the concession, unless earlier taken over by the state under the provisions of section seven of this act, the period of termination being determined by the State Water Storage Commission at the time of their approval of the concession in question.

At the expiration or earlier termination of any concession, all rights under the concession shall revert to and become the property of the state upon the state making just compensation for the physical property to the person, firm, or corporation, in accordance with the provisions of section nine of this act; provided, however, that the State Water Storage Commission may extend the concession under the terms of this act, and if the holder of any such concession, during the term thereof, has complied with all the laws and regulations, said holder shall have a preference right to renew the concession on reasonable terms laid down by the commission, and in case said holder declines to accept the new concession, the State Water Storage Commission shall elect whether the state shall take over the physical property in accordance with the provisions of section nine of this act, or whether it shall grant another concession, in which case the original concessioner shall have the privilege of selling or disposing of his buildings and machinery to his successor in concession.

Section 11. Every person, firm, or corporation, except municipal corporations, engaged in the development of water power, shall, in lieu of all other forms of state taxation, pay to the state of Maine an annual tax on or before the second day of January of each year, of not less than one half of one per cent. or not more than five per cent. of the gross annual income of said person, firm, or corporation, or if the power is used by the owner and not sold, the annual tax shall be at the above mentioned rates but based on an appraisal of the value of said power as determined by the State Water Storage Commission; provided, that, in the case of a disagreement on said appraisal, recourse may be had to a board of arbitration as provided for in section one. The rate of taxation may be on a sliding scale but shall be fixed by the State Water Storage Commission. The said commission may also determine at what future dates the rates may be readjusted within the above limits.

Section 12. If any person, firm, or corporation shall fail to pay the annual franchise tax as provided for in section ten of this act within ninety days after the same is due and payable, the state shall have a preference lien therefor, prior to all other liens or claims, upon all the property of said person, firm, or corporation and upon notice from the State Water Storage Commission the attorney-general shall proceed to enforce the lien and collect any unpaid fees in the same manner as other liens on property are enforced.

Section 13. It shall be the duty of every person, firm, or corporation granted a concession under the terms of this act, to keep such accounts and records as may be required by the State Water Storage Commission, and to report the same together with such other information over affidavit, as may be required by said commission on suitable blanks to be furnished by the commission and at such times and dates as may be specified by said commission. The failure upon the part of any said person, firm, or corporation to comply with the provisions of this section shall be deemed a substantial non-compliance with the provisions of this act, and of the concession granted to such person, firm or corporation.

Section 14. Whenever the owner or owners of any dam or dams used for the purpose of developing water power in this state, or the creation or improvement of any water storage basin or reservoir, find that, for the purpose of creating, acquiring, maintaining and operating their dam or dams and other works, it is necessary to overflow certain lands, said owner or owners shall apply to the State Water Storage Commission for the right to take and use any lands, riparian or other rights, that may be required for the creation, construction and maintenance of any and all reservoirs, dams, and other structures and improvements that may be necessary to accomplish the purposes of their charter, and after the approval of the majority of the members of the State Water Storage Commission has been given and a certificate has been issued stating that said commission does approve the taking or overflow for the particular purpose stated, then and not until then, the said owner or owners of the said dam or dams may proceed to exercise the right of eminent domain for the particular purposes stated in accordance with the provisions of Chapter 94 of the Revised Statutes and laws amendatory and supplementary thereto; provided, however, that the rejection of the application for the said taking or overflow shall be on the ground of the inadequacy of the engineering features of the plans, unless a great pond or state land or public lot or lots are involved; and provided, further, that in the case of the rejection of the said application for the said taking or overflow on the ground of the inadequacy of the engineering features, recourse may be had to a board of arbitration as provided for in section one.

Section 15. Whenever any person, firm or corporation contemplating the erection or the enlargement of any dam or dams for the purpose of developing water power in this state, or the creation or improvement of any water storage basin or reservoir, find, that for the purpose of creating, acquiring, maintaining, and operating their dam or dams and other works, it is necessary to overflow any great pond or take or overflow any public lot, lots or state lands, said owner or owners shall apply to the State Water Storage Commission for such rights of taking or overflow.

The said commission may make an engineering investigation of the desirability or necessity of such taking or overflow, and report to the next legislature the results of its investigations together with its recommendations for or against the said taking or overflow and include in said report its estimates of damages if any state land or public lot or lots are involved.

Section 16. In case the owner or owners of any dam or dams used for the purpose of developing water power in this state, or the creation or improvement of any water storage basin or reservoir, shall create, improve or increase storage on any great pond or any reservoir created for the storage of water, said owner or owners shall be entitled to be reimbursed by the treasurer of the state of Maine on warrants drawn and approved by the Governor with the advice and consent of the Council for all reasonable costs of operation and maintenance and a net annual return for twenty years of five per cent. on the cash actually spent in creating, improving, or increasing said storage. All owners or lessees of each and every improved water power operated for over eight months in the year, located below said reservoir or reservoirs or storage basin or basins and benefited thereby, shall pay into the treasury of the state of Maine his or their proportionate share of all the reasonable costs of operation and maintenance and a net annual return for twenty years of five per cent. on the cash actually spent in creating, improving, or increasing said storage, including the cost to the state of the supervision and regulation of said reservoir or reservoirs or storage basin or basins. The apportionment of the said reasonable costs and the said annual return of five per cent. shall be made by the State Water Storage Commission in proportion to the resulting benefits.

If any said owner or lessee of any improved and operated water power fail to pay his or their proportionate share of all the reasonable costs of operation and maintenance and a net annual return of five per cent. on the cash actually spent in creating, improving, or increasing storage from which they are benefited, within ninety days after the same is due and payable, the state shall have a preference lien therefor, prior to other liens or claims, except for taxes, upon all the property of said owner or lessee, and upon notice from the State Water Storage Commission, the attorney-general shall proceed to enforce the lien and collect any unpaid fees in the same manner as other liens on property are enforced.

Section 17. Every person, firm, or corporation engaged in the generation of electric current in this state shall install, within three months of the date of approval of this act, suitable and accurate meters and other instruments approved by the State Water Storage Commission, adequate for the measurement of the electric energy generated, and such person, firm, or corporation shall keep accurate and sufficient records showing the quantity of electric energy generated each day in the year and the number of hours run per day, and report same to the State Water Storage Commission on blanks prescribed by, and at such time as shall be determined by, said commission; provided, that in case any person, firm, or corporation engaged in the generation of electric current in this state fails to install suitable and accurate meters and other instruments within the time above specified, such person, firm, or corporation shall be subject to a penalty of $10 per day for each and every day over the above limit of three months, during which they have not made the necessary installation, said penalty or penalties to be paid into the treasury of the state of Maine; and provided further, that the State Water Storage Commission may extend the time before the penalty attaches in which to install the suitable and accurate meters and other instruments.

Section 18. Any party, feeling himself aggrieved by any act done, or failure to act, or by any findings or rulings made by the State Water Storage Commission, subsequent to the granting and acceptance of the concession as provided in this act, shall have the right to appeal to the Supreme Judicial Court in the county in which its dam is located, or at its option in Kennebec County.

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DISCUSSION.

MR. MORRIS KNOWLES.* I have been interested in the change of view between what has been and what is proposed, in the new Conservation Act now being recommended in the state of California. It is now planned to place in the control of one body of five men versed in various classes of conservation, the duties and authority formerly residing in the Board of Forestry, Redwood Park Commission, Fish and Game Commission, Water Commission, and present Conservation Commission. The duties of these boards are to be conferred upon the new board with broader powers and privileges.

I desire, however, to speak particularly at this time of the necessity of some legislation in our states that will promote development of the water resources by private capital under reasonable regulation; so as to prevent exploitation and secure at the same time to the people such desirable benefits as come from regulation of stream-flow; the prevention of floods, dilution of pollution, better navigable stages, as well as others that will be obtained when we have state-wide regulation. This is the reason for the formation of the new organization in our state, called the Water Conservation Association of Pennsylvania, of which I have the honor to be president.

A group of capitalists and publicists, realizing the good to come from a common meeting ground to discuss these problems of vital importance to investors and the people, met to consider this question, and formed this unique organization in which many minds are represented upon the executive committee. It is planned to conduct a state-wide campaign of publicity and education; with the expectation of thus securing, by coöperative effort, certain legislation at the next session of the state legislature which will bring order out of chaos as to water laws (the right of eminent domain as to appropriation of water, under-lands, and rights of ways does not exist with companies formed since 1905), to attract capital to develop the state's water resources; — but, at the same time, reserve to some tribunal the review of the exercise of the right of eminent domain and not only supervise the design and construction of dams (as recommended by Mr. Chandler and Professor McKibben), but also the operation thereof, so as to prevent floods and secure regulation of stream-flow.

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* Director Department of Sanitary Engineering, University of Pittsburgh, Pa.

I have been much impressed with Mr. Babb's well-thought-out plan of procedure, as explained in his paper; but, perhaps because our customs may not be the same as in Maine or because we have not yet given so much consideration to the subject, some few of the provisions suggested seem to be, upon first reading, either conflicting or unnecessary, in the light of the modern development of the true idea of conservation. While the speaker wishes to express the strongest agreement with certain parts of the paper, he would like to ask, without any spirit of antagonistic criticism, but with the attitude of inquiry, questions about certain clauses.

Section 1. The provisions in the second paragraph of this section — relating to the control over the uses of water, that the greatest benefits shall be derived therefrom for all users — are excellent and directly in line with the principles advocated by the Pittsburgh Flood Commission, and they have recently been incorporated in two charters lately granted by the Water Supply Commission of the state of Pennsylvania.

Section 4. The provision herein stated that district superintendents shall be appointed from lists of persons, recommended by various water users, — such as log-driving associations, reservoir, dam, and power owners, — is a recognition of the point of view, not to say the rights, of the practical operator, which is only too often forgotten in such legislation.

Section 6. The provision that copies of plans, showing design and location and nature of proposed work and structures, shall be filed and then "receive the approval of the majority of the members of the said commission" is just what Professor McKibben has been advocating and is much better than the Connecticut system, where any one member of the commission may approve.

Section 9. The arrangement for a purchase by the state, herein mentioned, is extremely vague, and it is difficult to imagine what may be meant by "*such franchises and rights,*" other than those conferred by the acts of the legislature, and the condition seems still more complicated by the statement in the second paragraph of Section 10, that just compensation shall be made for the "*physical property.*" If it is intended to mean by these terms that there shall not be any value, other than that of the physical property, as properly determined, allowing nothing for "development, expense," or "business value," it hardly seems that the provisions are fair to the investor of capital, which must stand early losses.

Section 10. If there be the right of purchase, as provided in Section 9, is there any need of the concession terminating at the end of twenty-five to sixty years, especially if there be a provision for the regulation of rates to be charged to the public? Earlier in the act, in Section 3, such business is declared a "*Public Utility,*" and it may be that some public utility law, not herein mentioned, provides for such rate regulation, but, in the absence of definite statement, we are not sure about this and it will be well if it can be cleared up. Does not the last provision of this same section permit of indefiniteness of construction and also permit a chance of a "hold-up" of the company whose franchise is expiring, or force it to sell out at a sacrifice to the company which secures the new franchise?

Section 11. An interesting query is raised with regard to this section, that if rates should be regulated, why should it be necessary to charge a tax upon the power company, either in proportion to the power developed or as a percentage of the gross receipts? With proper state regulation, such expense of course must be borne by the rate payer, but assuming it to be fair, is there any reason why municipal corporations which develop power should not be similarly taxed? Are they not doing a commercial and not a municipal business in such a case?

Section 14. The provision for a review of the exercises of the right of eminent domain is directly in line with what is now proposed in Pennsylvania, but the more cumbersome provisions of Section 15, which means going to the legislature for action, can hardly be as satisfactory.

Section 16. The provisions herein listed are much like the arrangements of the *Genossenschaft* of Europe, namely, "Associations not for profit," which bring about the coöperative effort of Capital, State, and People, in securing profits from investments and great benefits. It will be very desirable if we secure some such legislation in this country.

There was one additional thing that Mr. Babb mentioned in closing which seems to me important, namely, that some of the penalties or punishments were not included in the bill with the idea that if they were perhaps the bill would not pass. The oft-repeated statement occurred to me in that connection, that it is not so much the punishment or severity of the punishment which is necessary as it is the certainty. I think in matters of this sort definiteness as to what is required is far better than indefiniteness, although it may have been thought to have been necessary to do some trading in order to get the thing through the legislature. I think it is extremely unfortunate, however, if they thought it necessary to do anything which might be a compromise rather than to have something which would be definite and which everybody could understand.

MR. P. P. WELLS.[*] I have listened to Mr. Babb's paper with very great interest as an evidence that the conservation movement has taken root in New England. Having been connected with it here in Washington for the past five or six years I am much interested in seeing it taken up in the section from which I come. I was glad to note, in looking over Mr. Babb's paper, the forethought with which the founders of the state of Maine and the state of Massachusetts had retained to the state the control of the " great ponds." It gives the state a grip on the situation that is lacking in southern New England so far as I know; and, also, I suppose there are still considerable holdings of public land in the state of Maine, which we have not in southern New England, and which again give the state jurisdiction like the jurisdiction which the Federal Government has in the West, where it is a landowner to such a large extent throughout the mountain region.

I particularly noted two or three matters mentioned in Mr. Babb's paper. One of them is the matter of the time limit of the franchise, which Mr. Knowles called attention to. Theoretically I agree with Mr. Knowles's suggestion that if you have competent regulation and competent provision for the public taking over by buying out any private enterprise of this kind on fair terms, no time limit is necessary. But such provisions are rather uncommon. I believe the state of Wisconsin in its public utility policy goes upon the principle that franchises are indeterminate, and that the state may purchase at a valuation based primarily upon the construction cost, or replacement cost, with due allowance for promotion costs and other legitimate expenses. I think in the present state of development of public opinion in most of our commonwealths the time limit is a valuable element in any legislation of this kind, because it serves to protect the public until such time as a more perfect system of regulation can be worked out after the Wisconsin system, and because it will automatically bring up to the public at some future day the question as to what the public interest demands with respect to the expiring franchises.

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[*] Chief law officer, Department of the Interior.

I was also particularly interested in the matter of the provisions in this proposed Maine bill for forcing contribution to the cost of storage. That matter has come under my attention a good deal with respect to operations where the Federal Government was concerned. We have had cases in the West where on certain streams storage was to be put in by one company and others would get the advantage of it, and it is perfectly obvious that equity demands a contribution on the part of the companies who get the advantage of the investment, who at present do not contribute to it.

In regard to state purchase, — I have already alluded to the right of the state to purchase, — it seems to me that that is a very valuble suggestion — perhaps not worked out fully in detail, and it is probably impossible to so work it out at this time.

I have heard what Mr. Knowles has said about the regulation of prices and of service by the state, and it seems to me that that is one of the most important things for the state to do at this time, — that where the state has jurisdiction because state assistance is necessary in the way of corporate charters, or in the way of the use of state lands or the use of these great ponds or otherwise, under those circumstances there should be a strict regulation by the state in the public interest of the service to be rendered and the prices to be charged.

I have given some attention to the control of water power since the year 1907, in several different capacities, so far as the

Federal Government is concerned, — first, in connection with the Forest Service, of which I was the law officer until 1909; and contemporaneously with that giving informal advice and assistance to the Power Committee of the Inland Waterways Commission, which was created by President Roosevelt in 1907; and then for more than a year as counsel for the National Conservation Association; and for the past year in the office of the Secretary of the Interior, so perhaps it would not be out of the way for me to briefly state here the water-power control problem from the point of view of the Federal Government.

The Federal Government has or claims jurisdiction over water power from two different sources: In the first place, as a landowner. Throughout the West, the Rocky Mountain and Pacific states, the United States is the principal landowner, and has in its ownership a large number of power sites. Pretty much all the undeveloped water power out there is in federal ownership. As landowner, the consent of the United States must be secured to any water-power development there. Some of that land is in National Forests, and the rest of it is for this purpose under the jurisdiction of the Secretary of the Interior. In either case the water-power development is regulated under an act passed February 15, 1901, which compels a person wishing to develop a power to come to the Federal Government and get a permit from the Secretary of Agriculture if it is in a national forest, or from the Secretary of the Interior if it is outside such limits. Now, until the administration of the national forests was transferred to the Secretary of Agriculture, by an act passed February 1, 1905, there was no attempt at what may be fairly called public regulation under this statute. When the jurisdiction was transferred, the Forest Service took up the problem of water-power control and worked it over with the companies, with the applicants for permits, and adopted regulations which were changed with experience, as necessity showed was expedient, until the result was regulations which are embodied in what is called the " Use Book " of the Forest Service concerning water power, and which can be procured by application to the forester, — a series of comprehensive regulations on the subject.

The Interior Department has never until very recently attempted any thorough-going regulation under that statute, but on the 24th of last month regulations were issued by the Secretary of the Interior, which are very much like the Forest Service regulations, and which do attempt regulation of this character. I would say briefly about these that they provide for a rental charge to the government for the use of government land and for a time limit of fifty years, or not more than fifty years, for the privilege. In that connection I want to say that the great defect of this statute is that every privilege given by it is expressly by the statute made revocable by the head of the department, and that for the past five years the administrative branch of the government has been recommending legislation to allow the issuance of permits which would be irrevocable for fifty years. We have not succeeded in getting that legislation, which is so essential to safety for the capitalists who invest; but in these regulations both departments have gone to the limit of their powers by indicating, as far as they can, that the intent is that the permit shall remain in force for fifty years. But of course no secretary can bind his successor in that behalf, in view of the express language of the statute. Then in these recent regulations by the Secretary of the Interior there is a provision for purchase by the Federal Government, by the state, or by any municipality, at a fair value, with a bonus of three fourths of one per cent. for every year of the unexpired term. That is, if there were twelve years of the fifty yet to run, we would ascertain the fair physical value of the works and add nine per cent., and the public could buy them at that rate. Also by these regulations the grantee is bound to submit to reasonable regulation of prices and service by the duly constituted authority of the state in which the service is rendered. Also the rentals may be readjusted by the department at the end of ten-year periods. I think perhaps it will be interesting to read that particular provision:

> "At any time not less than ten years after the issuance of final permit and after the last revision of rates of rental charge thereunder, the Secretary may review such rates and impose such new rates as he may decide to be reasonable and proper; *Provided*, that such rates shall not be so increased as to reduce the margin of income from the project over estimated and proper expenses (including reasonable allowance for repairs and renewals) to an

amount which, in view of all the circumstances (including fair promotion costs and working capital) and risks of the enterprise (including obsolescence), is unreasonably small, but the burden of proving such unreasonableness shall rest upon the permittee."

Now; under the terms of this statute it is impossible to give jurisdiction to the courts in such a matter. These questions as to what is reasonable and proper must, therefore, be decided by the Secretary. The desirable arrangement would be to have the decisions as to what is fair rental, and the reasonableness of these various items, passed upon by the courts, and it is hoped that we will get legislation from Congress which will authorize such an arrangement.

There is another basis for the federal policy of water-power control which I will briefly mention, and that exists where navigable streams are concerned. I have scrutinized, I think, every bill introduced in Congress since the fall of 1907 granting licenses for the damming of navigable streams. There has been a legal contest waged around the question whether the Federal Government has any right to attempt any control in such cases, but after a good deal of hesitation and difference of opinion on the part of the government officers, the policy has been established by this administration — and I may say it was established by the preceding administration — of refusing such a license without express provision for regulation of this kind, — the requirement of a rental charge and provisions to protect the consumers of the power. In pursuance of that policy, bills granting such licenses, which did not contain those requirements provisions, have been vetoed during the past session of Congress.

Prof. Philander Betts.* This suggested bill apparently assumes the enactment shortly of a bill providing for a Public Utilities Commission. In connection with the definition of a public utility given in Section 3 of this suggested act, I want to state the experience of the New Jersey Commission. A public utility in New Jersey is defined by the Public Utilities Act in such a way that municipalities or municipal corporations are not included. Complaints have been made to the board at various times regarding the service furnished by municipalities, and the board has been powerless to entertain complaints of that kind. It seems absurd that in exercising regulation over public utilities such regulation can only extend to privately owned utilities, — utilities operated by means of capital furnished by private individuals. It seems to me that such regulation, if regulation is justified, and to-day we consider that it is, is justified because of the character of the services themselves. These services are public utilities, and therefore should be subject to regulation. The Wisconsin law clearly recognizes this by making no difference as to who operates the public utility, whether it is operated by a private corporation or by a municipal corporation. I would make the suggestion, therefore, that this proposed bill ought to be amended, if possible, so as to include public utilities, no matter who operates them.

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*Chief Engineer of the New Jersey Public Utilities Commission.

Another suggestion is in regard to the clause limiting the term of the franchise. A good deal has been said in the last few years regarding the terms of franchises. In years gone by, many franchises and charters had no limits, and the tendency at the present time with municipal corporations is to go to the other extreme and to limit the term in which the franchise may be exercised to a period too short to justify a company in making the investment to furnish a proper service. I would commend for consideration by every one interested in operation of plants, as well as by those interested in the enactment of public utility laws, the provision of the Wisconsin law for an intermediate permit, or for a permit unlimited during good behavior. All franchises for a definite term ought to include some provision for the period following the termination of the franchise. If this is not done, and there is any uncertainty with regard to the ability to obtain a renewal of the franchise, the temptation on the part of the company will be to stint the service and to withhold the expenditures of money required in making extensions and in keeping the service itself up to the point of adequacy.

Mr. M. O. Leighton.* Mr. Babb in his paper has admirably covered a difficult field. He has quoted a large number of court decisions relative to water rights, and they are very instructive. They are instructive largely because they reveal many difficulties and absurdities. I shall surely be criticised when I state that the greater part of our difficulties in the eastern part of this country arises from the fact that we are governed by one of the most abominable of our abominably revered institutions, namely, the riparian law. When we have jockeyed about to our satisfaction and have become convinced that water is the property of the whole people and must rationally be devoted to the highest use without regard to precedent, we will abrogate the riparian law and the entire principle underlying it. It will be very difficult to accomplish such a purpose because of our conservatism with reference to changes in fundamental law.

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* Chief Hydrographer, United States Geological Survey.

Our friends in the legal profession are always prone to regard the law as the end rather than the means. Their habits of mind are not unlike that of the miser who is gloating over his gold. His attention is fixed on the gold, not as a medium of exchange, but as a mere substance, the presence of which gives him satisfaction. In like manner we are prone to consider the law, not as a means to an end, not as a servant created to assist us in realizing our needs and desires in the wisest way, but as a final and unchangeable institution, to which we must bow and worship. Of course, I am now referring to fundamental law which lies at the basis of all our jurisprudence. I am unable to understand why we should be expected to direct all our constructive procedure according to the precedents established by the law of an earlier day and at the same time be considered unprogressive should we endeavor to utilize old methods of transportation in the conduct of modern business.

My point will be illustrated by quoting from one court decision cited by Mr. Babb. The case was evidently one in which complaint was made that a dam obstructed the use of a river for log-driving purposes. The judge instructed the jury that if the river in its natural state was capable of being useful for floating boats, logs, etc., for purposes of trade or agriculture, the plaintiff was entitled to recover however long the dam of the defendant might have stood and notwithstanding his use of the river had been open, notorious, and adverse, and although no logs had ever been floated over the falls where the dam now is. (Knox *v.* Challoner, 42 Maine, 150.) The merits of this particular case are of no immediate importance, but I would like to call your attention to the fact that here is a decision — and there are many others — which establishes the principle that the prior use of this river must be for navigation purposes, or log-driving purposes, irrespective of the facts and merits in the case. No matter how detrimental this prescribed prior right might be to the community, no matter how many people might be injured, or how insignificant was the log-driving use, that use is prior to all others merely because under the conditions which prevailed in an earlier day, navigation was considered paramount. Why should this be so?

Another illustration may be given. In those cases in which adverse decision has been made on the principle of compensation in kind, does it not appear absurd that a riparian owner can enforce his right to have a river flow by his property in its natural condition and be entitled to recover damages even though a corrected condition — brought about, for example by the construction of a reservoir — makes the river more valuable to him than it was before? In the state of California a great fertile valley is throttled in its development because of just such a decision.

Having observed closely the principle of prior appropriation based on beneficial use which prevails in the most of our western states, I cannot fail to recognize its superiority. It may be instructive to consider one of the state's laws based on this principle. Let us choose for convenience the law of Oregon. The act providing for the granting of franchises of water power begins as follows:

> " All water within the state from all sources of water supply belong to the public."

Section 45 of the Oregon water law reads as follows:

> " *Application.* — Any person, association, or corporation hereafter intending to acquire the right to the beneficial use of any waters shall, before commencing the construction, enlargement, or extension of any ditch, canal, or other distributing or controlling works, or performing any work in connection with said construction, or proposed appropriation, make an application to the state engineer for a permit to make such appropriation. Any person who shall wilfully divert or use water to the detriment of others without compliance with law shall be deemed guilty of a mis-

demeanor. The possession or use of water, except when a right of use is acquired in accordance with law, shall be *prima facie* evidence of the guilt of the person using it."

The Oregon law goes further. Should you have what would be considered in the East a riparian right and desire to develop a water-power privilege existing on your own land, and should you in conformity with the Oregon law apply for a permit to use the water and be granted the same, you cannot congratulate yourself that you have a permanent right. Section 53 of the Oregon law reads:

" *Water-right Certificate.* — Upon it being made to appear to the satisfaction of the board of control that any appropriation has been perfected in accordance with the provisions of this act, it shall be the duty of the board of control to issue to the applicant a certificate of the same character as that described in Section 25. Said certificate shall be recorded and transmitted to the applicant, as provided in said section. Certificates issued for rights to the use of water for power development acquired under the provisions of this act shall limit the right or franchise to a period of forty years from date of application, subject to a preference right of renewal under the laws existing at the date of expiration of such franchise or right."

The appropriation of water under such a statute is based entirely on beneficial use. No right is granted for a larger amount of water than can be beneficially used for the purpose for which it is desired. With such a fundamental principle established in the East, it would be impossible to sustain a water right which was not conducive to the best interests of the people as a whole; it would be impossible to use the common law as a basis and pretext for petty blackmail as is now done, the power developer and investor would benefit by the assurance of stability given under the law, and the people as a whole would be assured of maximum benefits resulting from the wisest use of their water resources. Such a change will not probably be made for several generations, but it is sure to prevail eventually.

MR. CYRUS C. BABB (*by letter*). The writer considers himself fortunate that he was able to be present at the conference, as a number of valuable suggestions were received from the various papers and their discussion. Consideration has been given from time to time to the several points raised by Mr. Knowles. In fact, most of the provisions of the entire bill have been rewritten a number of times. Section 9 is the usual form now inserted in legislative charters for large water storage or power companies, except modified to fit general conditions. This section, as well as the second paragraph in the next section, has been troublesome to write. It is not intended to exclude development expense, but to pay the "fair value," excluding, however, franchise value, which is used in its narrow meaning, that is, the intangible value of the franchise or right granted by the legislature. It is the people that grant the franchise, and it is believed that when they purchase the plant, they should not pay for a right that they granted in the first place.

The term "physical property" in the second paragraph of Section 10 was an error. It should have been the fair value of the property with the franchise value excluded. Probably the last provision can be made clearer. The intent is to give the holder of the original concession the preference right to renew. If he declines, allow the state to purchase, but if the state is not ready for such action, provide for its purchase by a third party.

The writer has had under consideration the "indeterminate franchise" as recognized by the Wisconsin Commission, but he wishes to understand the practical workings of it before adoption. At the present moment a limited franchise or concession seems to safeguard better the public's interest. Sixty years hence, our idea of the value of water power may be changed from what it is now.

Section 11: The tax on water power is a special tax from which it is believed the state should receive a revenue. It will not be so heavy — varying, on a valuation of $20 per horse-power, from 10 c. to $1.00 per horse-power per year — that it will be a burden on the people who derive a benefit from its development. Those people who do not receive the benefit, say, of electric power or electric lights, will not be taxed for it.

Without question, eventually it will be best to bring municipal plants under the operation of this section.

Section 15: The provisions of this section were a compromise.

The state of Maine jealously guards the granting of charters for developing its great ponds especially, and with a new and radical measure of this sort it was thought best not to insist that the Commission be given the power to grant such charters as the first draft of the section contemplated. It will be a long step in advance if persons or corporations desiring to create storage on a great pond be compelled first to apply to the Commission, who may then make an engineering investigation of same and report to the next legislature. It is probable that nearly all important measures that pass state legislatures or even the United States Congress are compromises to a certain extent. In the case of a meritorious measure it is generally possible to eventually improve it by subsequent legislation.

STATE SUPERVISION OF DESIGN, CONSTRUCTION, AND OPERATION OF DAMS AND RESERVOIRS.

BY FRANK P. MC KIBBEN, PROFESSOR OF CIVIL ENGINEERING,
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[*Read September 18, 1912.*]

THE RELATION BETWEEN THE STATE AND ENGINEERING CONSTRUCTION IS UNSATISFACTORY.

That many engineers are dissatisfied with conditions existing in the several states as regards the relation of these states to engineering construction which affects the body politic is shown by numerous discussions of state supervision of engineering works during the past year. These discussions were precipitated by the disaster at Austin, Pa., in September, 1911, when the failure of an unsafe dam revealed the astonishing condition that in the great Commonwealth of Pennsylvania a structure which endangers the lives and property of many people can be built in certain locations by any person whatsoever, and used without the least semblance of supervision on the part of the Commonwealth or any other competent authority. It makes no difference whether the builder be entirely ignorant of dam construction or not; he is perfectly free to erect a dam in those streams which have not been declared public highways by the legislature. Of course in such a case the public endangered has certain legal means of protection if it is made aware of its predicament, but such machinery is too complicated and inefficient to be worthy of consideration in connection with proper protective measures.

The engineering profession must have some form of supervision of structures possessing inherent danger, not only to secure better protection to life and property, in itself sufficient reason, but to prevent the erection of such structures by incapable persons, who, posing as engineers, thus reflect on the engineering profession as a whole. The Engineers' Club of Philadelphia recognized the need of more efficient methods than those existing for securing engineering works of greater safety when it passed the following resolution on December 9, 1911:

> "Whereas, the failure of the Bayless Pulp & Paper Company's dam on Freeman's Creek above Austin, Pa., on September 30, 1911, calls attention to the importance of insuring the safety of such structures where failure is a serious menace to human life; and, whereas, such structures should be entrusted only to engineers of ability and experience, who should have constant supervision of every phase of the construction; therefore, resolved, that the governor of the state is requested to call together a special commission of competent engineers, aided by legal talent, to frame comprehensive regulations providing for the creation of a permanent State Department of Public Works, to be composed of bureaus so constituted that their combined jurisdictions shall cover not only the construction of dams, but all other engineering contingencies likely to arise in the near future."

The Engineers' Club of St. Louis realized that a better system is necessary when, on February 18, 1910, action was taken favoring and urging

> "the passage of such laws by Congress as will provide for a department or bureau of public works which shall include the Coast and Geodetic Survey, the Geological Survey and the Reclamation Service, River and Harbor Improvements, and such other branches of other departments as may be rationally coordinated under the one general department or bureau of engineering and construction."

The same dissatisfaction is apparent in Mr. Alfred Brooks Fry's letter to Governor Dix of New York when, on December 11, 1911, he proposed a State Department of Public Works consisting of a commission of five members with the necessary chief engineer and assistants to carry on all state public work including the state public buildings, the construction, operation, and maintenance of state canals and waterways, to perform the duties of the present Highway Commission, State Conservation Commission, Superintendent of Public Works, State Engineer, and State Architect, etc.

All these citations indicate a desire for more careful supervision of engineering construction, and limitation of the right to build hazardous structures. Events of the past year clearly indicate the existence of this desire, but it is quite certain that if the engineers of the several states accomplish anything it is essential that united action of all engineering societies within those states must be brought to bear on their respective legislatures and that society resolutions and requests must be accompanied by personal solicitations on the part of individual members. The mere passing of resolutions will not be sufficient. And so it is with national legislation. Only by concerted action of many engineering societies, and by repetitions of their demands can anything be accomplished. If better state supervision of dams be desirable in Massachusetts, for example, the combined action of the Boston Society of Civil Engineers, the New England Water Works Association, and the engineering schools is required. These organizations must first reach an agreement as to what is best before they can go before a legislative committee to advocate improvements. Furthermore, it is only through national organizations acting in conjunction with local societies that anything like uniformity can be secured in various states. For example, if the two New England bodies just mentioned were to agree with the American Society of Civil Engineers on some form of state supervision of engineering works, and if similar action were taken between the national society and other state or local organizations, a great deal could be done towards securing uniformity in the different states.

In Pennsylvania there are four leading engineering societies, — the Engineers' Club of Philadelphia, the Engineers' Society of Pennsylvania, the Engineers' Society of Western Pennsylvania, the Engineers' Club of Northeastern Pennsylvania. These organizations, reinforced by the American Society of Civil Engineers, can and should take such action as will strengthen the status of public engineering procedure in the Keystone State. A joint committee representing the four state societies should decide on what legislative action is desirable relating to the formation of a State Department of Public Works which shall have supervision over all engineering matters coming under state jurisdiction. Armed with a proposal ratified by the engineering societies of the Commonwealth, the committee could appear before the legislature with such force as to command respect, but if each organization individually requests a different procedure it is perfectly evident that no action of importance can be secured.

WHAT ARE THE CONDITIONS AS TO STATE SUPERVISION OF DAMS AND RESERVOIRS?

There are three main divisions into which a study of this question may be divided: first, the safety of the structures; second, the use of water for power, irrigation, ice harvesting, or recreation; third, the use of water for public water supplies. It is only with the safety of dams and reservoirs that the present paper deals, although the two other divisions are none the less important.

The following twenty-seven states have laws intended to provide supervision of dams and reservoirs: Colorado, Connecticut, Florida, Georgia, Idaho, Indiana, Kansas, Maine, Massachusetts, Michigan, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Wyoming.

These laws vary in value from the rigid Colorado law, which invests the state engineer and district water commissioners with great powers, to the obviously cumbersome inefficient method of local control by county courts or county commissioners. Fifteen states provide for state supervision, and twelve place local officials in control. Of those states having state officials or boards nine are west of the Mississippi River, and it is generally true that the laws of these western states are more rigid, more carefully and explicitly framed than those of eastern states. This is probably due to the fact that most of those in the western group are semiarid, where regulation of water collection and use necessarily receive greater attention than in the East, where, because water is more plentiful, the subject has not received much consideration.

The laws of Oklahoma and Colorado are among the most stringent. They require preliminary approval of plans and specifications of dams and reservoirs by a state engineer, provide for his supervision during construction, and require a certificate of operation from the state engineer before the reservoir may be used. The Colorado law contains articles covering the following points: State engineer must pass on all plans and specifications of reservoirs of capacity more than 75 000 000 cu. ft. of water, or having a dam or embankment in excess of 10 ft. in vertical height, and covering an area of more than 20 acres; he acts as consulting engineer during construction; has authority to require satisfactory materials and work of construction; must give owners a written certificate of acceptance upon completion of work; must annually determine amounts of water which it is safe to impound in the several reservoirs of the state. It is unlawful for owners to store water in excess of amounts specified, and water commissioners must withdraw excess waters if any exist; upon complaint of three or more persons residing or having property in such places as would be endangered by breaking of a dam or embankment the state engineer must examine the structure and if he finds it unsafe he must immediately cause water to be lowered to a safe level; appeal from decision of the state engineer may be made to county or district court, but judgment of the state engineer shall control until final settlement. Each county surveyor must inspect annually the reservoirs within his county and report his findings to the county commissioners, and if the owner or tenant of an unsafe reservoir or dam, after due notice, refuses to remove the danger, the county surveyor must lower the water to safety. The act states that its provisions shall not be construed as relieving owners from payment of damages caused by breaking or overflowing of dams or embankments, and makes owners liable. Owners of reservoirs pay actual expenses of state engineer in making personal inspection and also a per-diem rate and expenses of any deputy; and persons making complaints about the safety of any structure as above stated must pay the state engineer's mileage to and from the reservoir in question. The state engineer may use force to carry out the provisions of the act if necessary, and a fine is fixed in case any reservoir company fails or refuses to comply with his notice.

If judiciously and conscientiously enforced, the Colorado law should give good results; but it would be better to designate to the state engineer those duties and powers now assigned to the water commissioners and county surveyors. Furthermore, the state and not individuals should pay expenses incident to examinations; and provision should be made concerning the reservoir owner's resident engineer.

Laws of the eastern states are generally inadequate. In Pennsylvania the State Board of Health passes on plans for reservoirs and appurtenances used for public water supplies, and the State Water Supply Commission by act of 1907 is invested with power of passing upon plans and specifications of dams to be built in those streams which have been declared public highways by the legislature. The Water Supply Commission has no power to supervise dams or reservoir embankments during construction, neither is it required to issue a permit for operation, nor has it the power to examine any existing dams, and has no jurisdiction over dams built before 1907. The concrete dam in Freeman's Run, at Austin, Pa., was finished in 1909, that is, subsequent to granting the power of approval to the Water Supply Commission; but the dam was not under the jurisdiction of that or any other commission, because the stream wherein it was located had not been declared a public highway. The failure of the dam just mentioned so aroused public opinion that the Water Supply Commission has made investigations of several dams suspected of being unsafe and it is also inspecting dams now under construction. It is quite evident that Pennsylvania has not sufficient protection against unsafe dams, but when the next legislature meets there should be no difficulty in securing additional enactments.

Whether this supervision will come in the form of enlargements of the State Water Supply Commission's powers or whether there will be a consolidation of several existing commissions into a State Department of Public Works remains to be seen, and the resulting action will be influenced by engineers only in so far as they act jointly through the various engineering societies of the Commonwealth.

The Water Supply Commission has done and is doing excellent work, and is amply able to carry out the statutes necessary to protect the state against repetition of Johnstown and Austin disasters. On the other hand, there are some strong arguments for combining several existing state commissions into a public service commission or into a department of public works. The inadequacy of present laws for safeguarding against dam and reservoir failures is duplicated in lack of provision for oversight of bridges carrying railroad trains and street railway cars, and the legislature should give consideration to these and all such questions at its next session. Whatever form of administration the needed improvements may take they should be so simple that a suspected dam would be examined without appreciable delay by a competent state engineer, and if the structure were found to be unsafe the commission should have authority to act speedily and effectively.

In the West all work executed under the Carey Act, a congressional act permitting private capital to irrigate and reclaim arid lands, is under supervision of state boards or state engineers who are given the power of approval of designs, and who are to see that the dams, reservoirs, and ditches are properly constructed and finished in accordance with the original plans. But as each state where the Carey Act applies has passed its own laws regulating the control of work within its borders, there are, in consequence, considerable variations in the operations of this act.

State supervision is not always sufficient, and federal control might be necessary. For example, when a dam is constructed in a river forming the boundary between two states, it would be under the jurisdiction of the United States War Department only when the stream is navigable. In other cases, if each adjacent state had regulations which were actively enforced, it might be very difficult or impossible to secure concerted action on the part of the two states; at any rate, there would be a chance for conflicting authority, and federal supervision may be desirable. Another case which might arise is that of an unsafe dam in one state put near the boundary, and so situated that in case of failure destruction of life or property would result in an adjoining state. Of course, if each state had adequate supervision little chance would exist of this contingency arising, but if the state containing the dam had no efficient means of insuring safety, an effective state board in the endangered state would not have authority to act, and recourse would have to be made to public opinion or to the courts.

AN OUTLINE FOR PROCEDURE IS RECOMMENDED.

Assuming that state supervision to secure safety of dams, embankments, and reservoirs is desirable, how can it be exercised? The following outline is suggested:

1. Examination of plans and specifications by a properly organized state board whose approval is necessary before construction is begun. This approval should carry the proviso that a competent resident engineer be employed by the owner continuously at the dam under construction.

2. Examination of the dam or embankment during construction by competent engineers in the employ of the board. Inasmuch as the majority of masonry dam failures have been caused by faulty foundations, it is quite evident that inspection of the foundation as well as the superstructure is necessary, and that the board acting through its chief engineer must have the authority to secure changes in plans and methods if geologic or other features of the site require such changes. To make state supervision complete and efficient, a capable state engineer must see the work at important stages. Changes in original plans and specifications should be permitted only when allowed in writing by the chief engineer, and after a dam is finished no alterations should be allowed except with the written consent of the board.

3. Upon completion of the dam the state engineer should examine the structure and should require a report from the owner's engineer that the dam was built in accordance with approved plans and specifications and that the structure is a safe structure for the purpose for which it is intended. If the structure and report be approved, the board should then issue a certificate of operation.

4. Biennially after the dam is completed the owners should be required to have a competent engineer examine the dam and reservoir and to submit his report, together with any recommendation, to the board. It is the purpose of these biennial examinations to reveal any changes in and about the dam or reservoir which might endanger the safety of the structure.

5. At intervals not greater than five years, and oftener if necessary, the state engineer should examine each structure, and his reports should be published in the annual report of the board.

In case any repairs are shown to be necessary, either by the owner's engineer or by the state engineer, the board should order the owner to make them or to lower the water, and if he refuses, the board should apply to the judge of the county court for enforcement. Furthermore, at any time upon petition of three or more residents or property owners who consider their lives or property in danger because of the presence of a suspected faulty dam, the state engineer should examine the structure, and if repairs are necessary the board should proceed as above. Nothing in the act should relieve the owner of his full responsibility for the safety of the structure.

STATE SUPERVISION IS DESIRABLE BUT IS NOT A PANACEA.

Many people believe it desirable to establish state control over such works as dams, reservoirs, and bridges because failures of these structures endanger life and property. Probably a very much smaller number of people hold the view that the state should exercise no control whatever over these works of engineering when owned by private interests. State ownership or control does not prevent all accidents. Nevertheless, the state, that is, the people acting through certain officials, should exercise some control over structures which involve potential danger from the fact that they confine great forces of nature which if not restrained would cause loss of life or property which because of their magnitude and peculiar nature have inherent danger. As population becomes more dense, state restrictions are the more necessary. It seems therefore that state supervision is justifiable and, if properly administered, is an additional safeguard to life and property, and if of such a nature as to be an additional factor of safety or to reduce the possibility of disaster, while not relieving the owner of his responsibility, it is certainly a very desirable thing to have.

No one familiar with the action of state departments or government control or government ownership believes that these are infallible agencies of preventing disaster, but the safe and sane position to take is that they simply serve as additional means of seeing that the engineer's ideas as embodied in his plans and structures are correct. The objection has been raised against state supervision that in case a structure were approved by a state board it might relieve the owner of damages if the structure later by failing caused loss of life or property. It is not a question of who is to be liable in case a structure falls down. It is a question of preventing its falling. Furthermore, with no supervision whatever in the case of Johnstown flood, no remuneration was forthcoming from the owners, and it is apparently true that those who suffered losses at Austin, Pa., will receive no payments for those losses. In both these cases the full responsibility rested on the owners, the state sharing none.

DISCUSSION.

MR. JOHN C. TRAUTWINE, JR. Mr. President, I have a special interest in Professor McKibben's paper; first, because I hail from that unhappy state whose plight he has so graphically described; a plight, which, however, judging from the papers we have heard read this morning, is shared by other states, notably by Connecticut, New York, and Maine.

Another reason for my special interest in Professor McKibben's paper is that I was the author of the resolution (though not of the preamble) adopted by the Engineers' Club of Philadelphia and quoted by Professor McKibben.

Professor McKibben remarks that the three utterances, that by the Engineers' Club of Philadelphia, that by the Engineers' Club of St. Louis, and that by Mr. Fry, all seem to aim at improvement in the safeguarding of dams. While this is true, the significant fact is that each of those three utterances aims at the substitution of order for chaos, — at the simplification and unification of the governmental process by which dams shall be safeguarded. It was just there that I, as the obstinate juryman, felt constrained to take issue with my colleagues on this committee of three appointed by the Engineers' Club of Philadelphia to consider the whole question of the inspection of dams. The result was my minority report, quoted below, and concluding with the resolution adopted by the club.

Our conferences, in committee, had not proceeded far before I discovered that it was impracticable for us, in the limited time allotted, to specify confidently, and in detail, what the state ought or ought not to do in the premises; and then the thought dawned upon me that, in seeking to draw up, at short notice, a program for the state to follow, in regard to dams alone, we were going about the matter in the wrong way; that, in the state administration of public works, we had a sort of crazy patchwork, and that what was first of all needed was unification in the state's engineering operations, as a whole, including not only the matter of dams, but all other technical matters, and that this work could not properly be performed in a few days by a club committee. I therefore submitted the following minority report, which I venture to submit as a contribution to this discussion.

1. In sparsely populated and agricultural countries, the individual needs but little protection from the state; but, as population becomes dense, as great corporations arise, and as structures are erected whose failure means great loss of life and property, the state is forced to assert itself more and more actively, and in new directions, for the protection of its citizens. At a country crossroads, traffic may be left to regulate itself. On Broadway, freedom of action requires that the will of the individual be subordinated to the autocratic control of the policeman.

2. We long ago recognized the necessity and propriety of governmental inspection of buildings, of boilers, and of elevators; we have more lately sanctioned inspection of foods, governmental regulation of railways, etc.; and now the failure of the dam at Austin, Pa., and the later failure of that at Macdonaldton, Pa., have reminded us sharply of the necessity for similar control over dams.

3. It might be argued that self-interest should lead builders of engineering structures to take sufficient precautions; but such disasters as the two mentioned and the collapse of the Quebec bridge show that we cannot safely rely upon self-interest of builders to work in that direction, or leave the design and construction of such works to their uncontrolled decision, and that the state, which can earn no profit by cheapening the structure, should have the final control.

4. State or national control of dams is therefore a public necessity and in line with the inevitable trend of society.

5. State control might be exercised by a state engineer of dams, by a standing or special board of commissioners for dams, by some existing branch of the state government, such as the Water Supply Commission, or by a State Civil Service Commission,

before whom all engineers should be required to qualify before being permitted to construct important dams.

6. (This is the significant preamble, containing the sentiment expressed by the St. Louis Club and by Mr. Fry.) But it is unworthy of the dignity of a great state that such matters are taken up in haphazard fashion, awaiting disaster in some particular class of structures, and then awakening to the necessity of providing against that particular form of catastrophe. Such a policy leads to the creation of a heterogeneous collection of imperfectly correlated governmental bodies, clothed with conflicting or overlapping powers and of very limited combined efficiency.

And it was for that reason that I urged the following, which was adopted as the sense of the club:

7. The governor of the state should therefore be requested to call together a special commission of competent engineers, from this or from other states, or both, aided by legal talent, to frame comprehensive regulations providing for the creation of a permanent State Department of Public Works, to be composed of bureaus so constituted that their combined jurisdictions should cover not only the construction of dams but all other engineering contingencies likely to arise in the near future.

Mr. M. O. Leighton.[*] Mr. President, governmental control is a somewhat peculiar and diverse subject concerning which there are many different opinions.

I believe it to be true that, if a man desires to be completely independent, he must live alone. His independence will always be compromised if he lives in the same locality with another person, and it will progressively decrease as the population increases, until in a large community that man finds himself hedged about with so many limitations upon his complete independence that it sometimes appears as though his whole life were governed by precepts and ordinances enforced in the interest of the other fellow. So by progressive stages throughout the entire history of the development of civilization it has been inevitable that individual interests must give way to common interests when the former are antagonistic to the latter. I believe that this is a crude expression of the principles governing community life. The facts constitute a justification for the governmental control of public utilities or the control of all matters in which many persons have a common interest. The safety, happiness, convenience, and progress of the people must be conserved by uniform regulations enforced by the people's representatives.

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[*] Chief Hydrographer, United States Geological Survey.

The facts given in the papers on the subject of control of dams demonstrate clearly the necessity for some control, and I personally believe that that control should be by the state when the matters are exclusively intra-state, and of necessity by the Federal Government when those matters involve interstate relations.

It is a curious fact that the construction of dams, upon the integrity of which the comfort and safety of so many people depend, is subject to little or no governmental control. Contrast this with the fact that if a man desires to build even a one-story structure in the city, he must usually build it according to certain regulations and limitations. If he wishes to hang a sign over the sidewalk the work must be done in a prescribed way because of the danger which might arise to the public in case that work were not done in a proper way. In many states and communities sanitary authorities control the construction of plumbing in buildings notwithstanding the fact that it has been demonstrated that bad plumbing has a remote if any connection with disease. I may go further and cite the fact that a man cannot operate a peanut push-cart in our large cities without securing a license and doing the work under certain regulations. In view of the fact that so many of these relatively unimportant matters are subject to governmental regulation, is it not strange that a man can erect almost any sort of dam that he chooses in nearly every state in the Union without adequate regulation? There are laws, of course, in many of the states, the names of which are given in Professor McKibben's paper, but notwithstanding these laws, there are examples of bad dam construction in nearly all of the states, which construction was performed openly. Of course, there is always redress in such cases on the part of the public, but the procedure is usually indirect and inconvenient, and it is very true that that which is every one's business usually turns out to be no one's business. Bad dams are erected in spite of the law and in the sight of the people.

The condition that I have described not only results in danger to human life but it greatly impedes progress in water conservation. Every one will agree that when a country becomes more and more thickly inhabited, it becomes correspondingly necessary to conserve water in reservoirs. That means the construction of dams It happens that in connection with some of my official work during the past few years I have advocated certain large reservoir installations. The idea has been fiercely combated by many good men, and it is noticeable that these men as a rule finally resort to a gruesome picture of the consequences of dam failure. It is a striking argument in the public mind. It is easier to discredit dam construction by doleful references to the few dams which failed than it is to support the idea by comforting references to the hundreds which have not failed. Of course we are bound to progress in the right direction irrespective of any specious arguments, but progress in the reservoir direction will always be impeded so long as the opponents find opportunity to cry " Wolf." It is necessary, therefore, to construct good dams in order to avoid the failures and to establish in the public mind the confidence in dam structures which under good engineering practice they fully deserve.

Among the states mentioned by Professor McKibben, there is one in which the regulations are supposed to be very good. In spite of them, however, an earthen dam was erected in that state not long ago which by reason of a fortunate train of circumstances came under the observation of two competent engineers before the outlet gates had been closed. One of the striking results of this examination was an experiment which they made to determine whether the dam would hold water. They excavated a hole in the ground at the upper toe of the dam, and found to their surprise that they could not bring water to that hole fast enough to fill it. It all seeped out under the dam. Of course, had the gates been closed, and had hydraulic pressure been put upon that dam, it would have failed and would subsequently have been cited as another example of the failure of *good* dam construction.

The procedure recommended by Professor McKibben for governmental control ought to serve admirably, but he is eternally right when he speaks of the lack of infallibility on the part of government officials who are supposed to guarantee the stability of dams. However faithfully a state engineer or an engineering commission may be, mistakes will be made. We have not reached the point of infallibility. Therefore the public at large must bear its share in the responsibility and take an interest in these matters even though they have apparently provided for safety through the enactment of suitable statutes and the appointment of suitable boards of control. As in many other features of public improvement, public instruction is necessary and all standards must be raised, the standards of the public as well as the standards of engineers. In the education of the public the procedure recited and recommended in Professor McKibben's paper will be effectual.

Dam construction involves three factors of personal control, — the owner or projector, the engineer, and the contractor. The owner will be suitably educated by the enforcement of the laws which regulate the construction of dams, if they are as good laws as they ought to be. The engineer must also be educated; he must qualify. You are familiar with the agitation concerning the licensing of engineers. I am not going into a discussion of that, but will state simply that I have yet failed to find any real reason for opposing such a project. We require a physician or a lawyer or a marine engineer or a pilot to demonstrate whether or not they can satisfactorily perform their duties before they are allowed to enter upon them. Why should this practice not prevail with reference to the civil engineer? Consider any of the dams that have been erected, especially in the eastern part of this country. What physician has so large a practice that there are dependent upon his wisdom in any one day, or in any one year, the lives of so many persons as are dependent upon the wisdom of an engineer when he builds a dam above a populated valley? Why should an engineer be allowed to build a dam if he is not qualified, and by *qualified* I mean qualified to build a dam. Engineers should be classified. The fact that a man is able to lay street pavements or to build a sewer system is no guaranty that he would be a satisfactory person to construct a dam. There is no particular difficulty in the classification of engineers according to their abilities. Such a procedure is already in effect in many lines of work. Take, for example, the marine pilot. If you will examine the license of a pilot in charge of a boat on the Potomac River you will find that license limits him to certain regions. He is confined to the Potomac River and possibly Chesapeake Bay, but he is not authorized to take charge of a steamer in New York Harbor or in Puget Sound. This classification of engineers would be quite as easy if the legislative procedure were properly outlined, and an engineer who undertakes a piece of work that may be hazardous to public safety may well be examined and qualified along those lines.

Consider the contractor. It is undoubtedly true that many dam failures have been caused by poor work on his part. You know the predicament of a contractor who is losing money on his job, and how easy it is to consider the fact that the poor devil *is* losing money and therefore to allow a little indulgence here and there. To secure a good piece of work under such conditions, eternal vigilance is usually necessary, and few of us measure up to eternal vigilance. One of the best ways to obviate such a difficulty is to abolish that absurd and antiquated regulation which prevails, especially in public work, that the contract shall be awarded to the lowest bidder regardless of the cost and the difficulties and regardless of the real responsibility of the man. In ninety per cent. of the cases, and probably more, the expense, trouble, and delay caused by a defaulting contractor who is awarded a job at too low a price, more than exceeds the difference between the successful bid and the rational one.

MR. EDMUND M. BLAKE.* The excellent papers of Mr. Chandler, Mr. Babb, and Professor McKibben, on the general subject of state control of the design and construction of dams, have been read with much interest, especially the reference in the latter paper to the methods of handling this important subject in the states west of the Mississippi River.

In the great arid region of the United States, on both sides of the Rocky Mountains, the annual precipitation is extremely low, and a very high value is consequently placed upon every gallon and every second-foot of water. As a natural result of this condition, the laws in general which have been passed by the legislatures of the arid states have been much more strict with reference to the means employed to conserve water than the few similar laws which have been passed in the eastern states. In most instances, as cited by Professor McKibben, the arid states have adopted effective and stringent laws bearing upon the design and construction of dams and reservoirs for the storage of water, with the provision for wide power to be exercised by state departments and state officials in these matters.

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*Assistant Engineer, Massachusetts State Board of Health.

The Government Reclamation Act, under which national funds are spent in the construction of dams, reservoirs, pumping plants, and canal systems for the irrigation of public lands, carries with it government control of the design and construction of all of the works. The splendid structures erected under the government engineers are a lasting monument to the excellence of their design and construction work, although money has not been spared where its use would increase the safety, permanency, and stability of the massive dams which store the water of the mountain streams for use in the arid plains below.

Paralleling the Government Reclamation Act is the very brief but far-reaching Carey Act, which makes it possible for private capital to engage in the reclamation of arid public lands, and the total acreage covered by work under the Carey Act is much larger than that covered by the Government Reclamation work up to the present time. The Carey Act gives the arid states the right to request the segregation by the government of areas of the public domain not already set aside by the Reclamation Service, and empowers the different states to control the works of reclamation by private capital of the lands so segregated. As Professor McKibben cites, each of the states in which work has been done under the Carey Act has passed its own special laws and regulations for the control of irrigation works. The writer is quite familiar with such laws as passed in Montana, Wyoming, Utah, Idaho, and Oregon, all of which differ materially from each other, but all of which, in the main, place in the hands of the state engineer the approval of plans and specifications for the construction of the works and direct him to make such inspections of the same as he may deem necessary or desirable.

In the state of Idaho, which has more than doubled in population during the last decade as the direct result of irrigation, the state law provides:

First, that the sufficiency of and title to the water rights for a proposed Carey Act project shall be approved by the state engineer;

Second, that the segregation of the lands requested shall be approved in final form by the government and the State Land Board; and

Third, that the irrigation company proposing to reclaim the lands shall enter into a definite contract with the state, approved by the Attorney-General, which contract must embody the plans and specifications for the construction of the proposed works in form passed upon and approved by the state engineer.

In the contracts of this kind with which the writer has been intimately familiar, the principal requirement of the specifications is that the combined natural flow of the source of supply and the amount in storage shall be amply adequate to furnish water at the point of delivery to the settler at the rate stipulated in the contract, which, in general, is one eighth of a second-foot per acre, continuous flow, and that the entire canal system shall have adequate carrying capacity.

As a general rule, the great desire of Carey Act companies to hold the opening public sale of their lands as soon as possible, for financial reasons, leads them to rush through the preliminaries of engineering investigation and detail design, with the result that the plans submitted for dams are usually of a very general nature and seldom anything like the plans under which the dams are finally constructed. It is, therefore, plainly seen how important becomes the power given to the state engineer in the matter of the approval of final plans for construction and the inspection of the work during all stages of its progress. Too often inadequate inspection is given to the nature of the geologic formation under the massive storage dams constructed on these private projects. Below most of these dams are located the newly organized towns which are to become centers of the industrial life of the new tract and to which the safety of the dams above them is absolutely essential.

As provision is made in the contracts with the state for transferring to the settlers under a Carey Act project all of the structures and works for irrigation, after the payment by the settlers of a certain percentage of their water rights, two things at once become evident; first, the patent desire of the private corporation to expend as little money as necessary to meet the final approval of the state; and, second, the importance to the settlers of being assured that what they are to eventually pay for, take over, operate, and maintain, shall be of a permanent and adequate nature. The accomplishment of this result, and hence the prosperity of the settlers on nearly 3 000 000 acres of land in Idaho alone, depends largely upon the supervision and control of the state engineer.

Right here comes the vital obstacle, in my mind, to the successful carrying out of even the most effective and stringent state laws for the control of the design and construction of engineering works, namely, the regrettable insufficiency of the money appropriated by the legislatures of the arid states for the use of the state engineer in the employment of skilled engineering services to properly inspect the construction of these dams at every stage from beginning to end. In general, the state engineers are men of experience and ability, but the position is an appointive one, liable to change at any election, and the duties imposed upon the state engineer are so varied and numerous, and call for his attention over so vast an area of land as is covered by most of the arid states, that it is absolutely out of the question for him to give effective personal attention to dams and reservoirs. His appropriation for assistants is generally limited, and the men employed, in general, are sadly lacking in the experience which such important works demand. The result has been that inspection during construction has been intermittent in most cases, and thereby inadequate and unsatisfactory. In the noted case of the Mackay Dam, on the Lost River Project, in Idaho, the inherent defects were not discovered until construction work was well advanced, at which time the entire project was held up and thousands of settlers were financially damaged. It was a noteworthy fact that, in this particular case, attention to the defects was made public by parties outside of the state officials and departments.

Similar instances might be quoted where lack of proper inspection by the state has resulted even more seriously, not yet in any notable failures of dams with resulting loss of life and property, but with reduced storage capacity and consequent loss to the settlers depending upon that storage at the critical stage of the irrigation season.

Familiarity with the conditions in these northwestern states has led me to the firm conviction that the remedy must come from a keener public sense of appreciation of the necessary and invaluable work of the engineer in safeguarding public interests by rigid inspection of the construction work on dams and reservoirs, with power to change plans and hold up construction work when necessary. This aroused public feeling would then result in the appropriation by state legislatures of adequate sums to attract and make it possible to employ skilled and adequate engineering service, without which the vast engineering works so vitally affecting the prosperity of the new communities of the Northwest will fail to accomplish the purposes for which they were originated. The fault lies not so much with the hard-working and generally able and honest state engineer as it does with the limitations which are placed upon him in the employment of skilled assistants through the failure of the general public to insist upon the appropriation of adequate sums by the men who represent them in the state legislature.

SOME FEATURES OF THE CONSTRUCTION AND FAILURE OF THE AUSTIN, PA., DAM.

BY T. CHALKLEY HATTON, C. E., WILMINGTON, DEL.

[*Read September 19, 1912.*]

The writer has deferred saying or writing anything about the failure of the Austin dam because of a pending suit against the owners, and his desire was to have this suit first settled.

It seems to be appropriate to here present some features of the construction and subsequent failure of the work as an argument in favor of Professor McKibben's proposition for state supervision of dams.

Several engineers who have publicly expressed their opinions of the cause of the failure of the Austin dam have made a very serious mistake in not differentiating between the failure of this dam and its demolition.

This dam failed January 23, 1910, and was demolished September 30, 1911, over eighteen months later. After January 23, 1910, the structure could not be termed a dam; it was a vertical wall broken in five or six distinct and separate sections. The same causes which effected the failure were only indirectly the cause of the demolition.

Having seen the dam very often during its construction, and during all of its stages; having been on the dam during its failure, and viewing its movement downstream, and having made as thorough an examination as possible the following day, after the water was emptied from behind it, I should be better qualified to determine the cause of its failure than those who have examined it after its complete demolition.

The Austin dam failed at the intake which was near the center of the spillway by dropping down at the toe some 6 in. and sliding out at the spillway about 18 in. The concrete did not slide on its sandstone base, but one stratum of the underlying sandstone slid

PLATE VIII.
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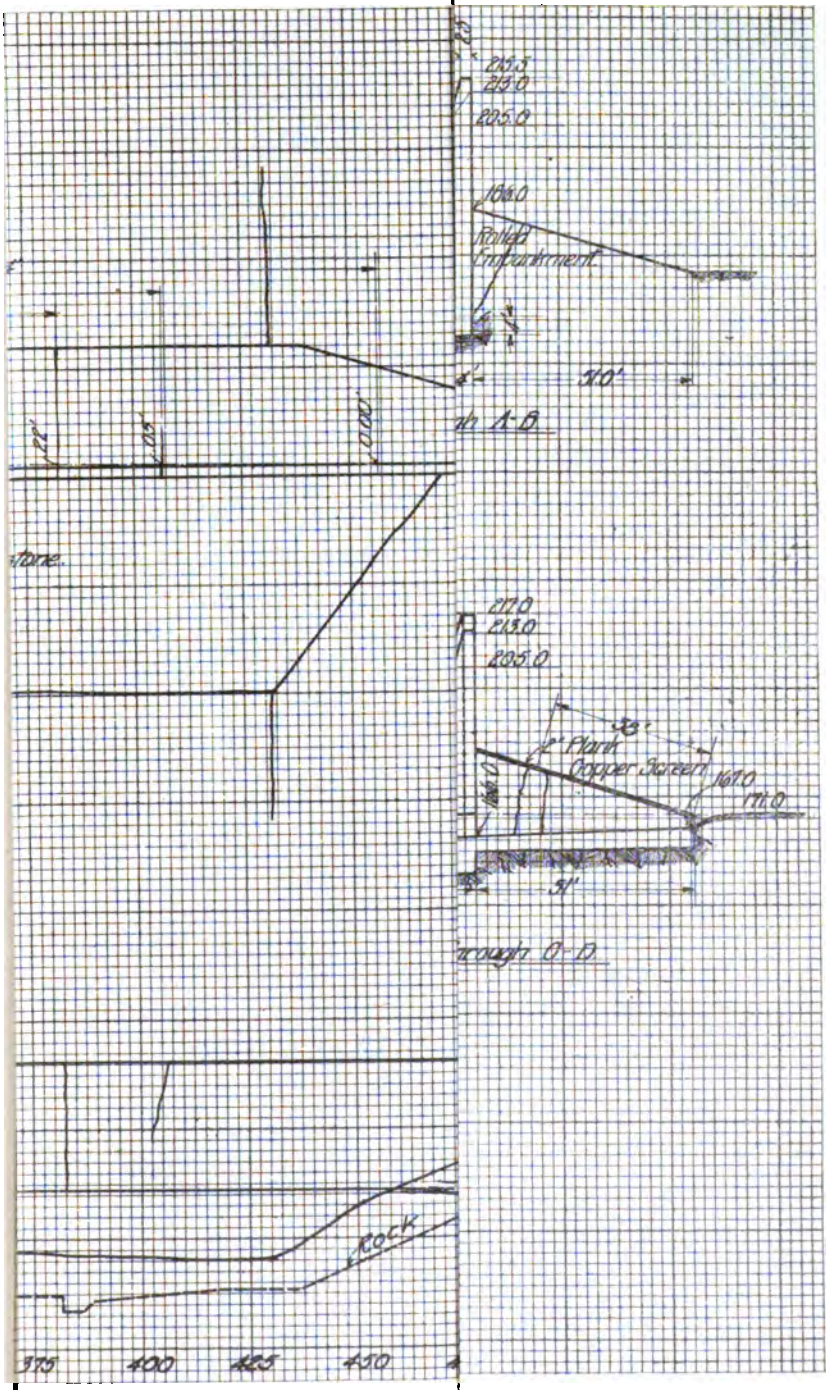


JANUARY 25, 1910, THE DAY AFTER ITS FA

upon another after the intervening stratum of shale and gravel had been softened by the water seeping through this stratum.

This result was very apparent on the morning of January 25, 1910, after the water was out. The intake walls, which were built against the upstream face of the dam, and at right angles thereto, were pulled apart near their center in an almost vertical separation 18 in. wide. The underlying rock stratum upon which this wall was built had a vertical cleavage parallel with the face of the dam, about 12 ft. upstream from it, immediately under the vertical separation of the intake walls, and of the same width. No better evidence could be obtained as to what happened when this dam failed.

The center of the dam bowed downstream about 31 in. at the top, the bow running to zero about 110 or 115 ft. either way. There were four or five vertical cracks entirely through the dam in this 220 or 230 ft., and one vertical crack nearer the west end which did not extend the full depth of the wall. These cracks divided the dam into five or six distinct and separate sections.

As the dam slid down in the center, the earth immediately below and adjacent to it was pushed up quite perceptibly. This earth and the underlying sandstone strata, against which the downstream face of the dam was built, was the only thing which saved the dam from total demolition in 1910.

Plate VIII is a plan made from measurements taken January 25, 1910, the day after the failure.

Since January 25, 1910, water has been constantly impounded by this broken concrete wall. The depth of this water has varied from 25 to 52 ft. During this period water has continued to leak through the underlying strata, and this leakage, going on at great pressure, must certainly have washed much of the shale and gravel away, leaving the heavy concrete walls with less and less foundation until the final collapse came on September 30, 1911. It is therefore not hard to imagine that the condition of the foundation at this latter date was far different from what it was eighteen months earlier. When the water reached its maximum height on September 30, 1911, it was simply a matter of first a dropping of the wall and then a movement of the different sections, resulting in stresses which could not be computed, and which would not have taken place if the wall had been a monolith, as it was on January 23, 1910.

So much for the difference between the failure and demolition of this dam; now I want to correct some false statements which have been publicly made by some of my professional brethren in their desire to determine logically the cause of the failure of the dam.

The conditions governing the design of the dam were not unusual. I had a client who placed upon me two limitations, minimum cost and maximum height. The first was $85 000 and the latter was determined by securing an impounding area of 200 000 000 gal. of water.

In order to fulfill these two conditions, I made three separate designs, reducing each cross-section a little until I got the least which I believed to be safe. This section did not provide for any leakage under the dam, nor did I expect it.

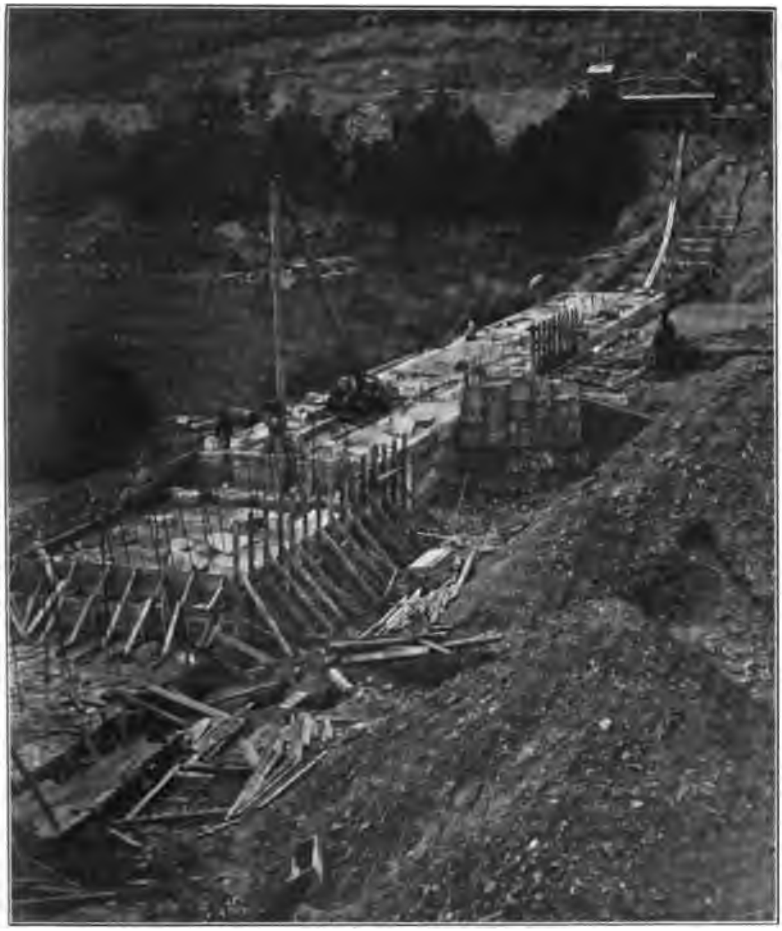
I knew the nature of the foundation, for I had sunk pits upon the site of the dam before designing it. I had also carefully examined the nature of the underlying rock, which could be clearly seen throughout the valley. I expected to prevent leakage under the dam by building a very stable upstream embankment against its face, which I also expected would reduce the hydrostatic pressure against the dam.

To increase the factor of safety against overturning, I placed steel rods in the upstream portion of the wall. These were 1¼-in. steel rods 25 ft. long, sunk 6 to 8 ft. in the underlying rock strata, and secured thereto by expansion bolts, the holes being filled with cement mortar.

To increase the factor of safety against sliding, a key or cut-off wall was built into the rock on the upstream face of the dam, forming a vertical projection of the dam. This wall was 4 ft. wide and from 2 to 4 ft. deep.

The weak part of the dam was at the intake, where there was no embankment against the upstream face, and where a hydrostatic pressure was exerted against the dam due to the full depth of water to its foundation, approximately 53 ft.

To overcome this extra pressure I built against the downstream face and over the full length of the spillway a heavy concrete wall 7 ft. deep. However, this is the point where the dam failed.



THIS VIEW SHOWS THE REINFORCEMENT, KEYWAYS AND LARGE STONES FORMING CONCRETE.

When this dam bowed downstream in 1910, there was a space left between the embankment and the face of the wall, leaving the embankment of no further use. I am quite sure, however, that this embankment did prevent leakage under that portion of the dam with which it was in contact, and, had the center of the dam held, the embankment would have fulfilled the purpose for which it was built. The next day after the failure I dug several holes in the surface of the embankment and found it dry 3 ft. deep, showing that very little penetration had resulted after two months' submergence. After the failure, this embankment still stood, and even after the demolition a large portion of this embankment is still standing. It was well built, with good material deposited in 6-in. layers and thoroughly rolled with grooved rollers.

The great mistake I made in building this dam was trusting to the rock foundation as being impervious. I am just as fully alive to this mistake as are several of my critics who seem to think a careful and experienced engineer could not have so erred in judgment; but I want to tell these critics a few things which influenced my judgment.

About 860 ft. above the site of the new dam another dam had been built some twelve or thirteen years before. This dam was 20 ft. high, and impounded about 26 000 000 gal. of water. It consisted of a rubble stone masonry core wall 12 in. thick on top, and stepped down to 4 ft. 6 in. on the bottom, which was built on the surface of the same sandstone stratum upon which the new dam was to be built. The dam had an embankment on the upstream face with a slope of 2 to 1. The embankment on the downstream face had been washed away, exposing about two thirds of the core wall.

The only place where this dam leaked was through an old clean-out pipe which had been abandoned, and which the owners had unsuccessfully tried to stop up. There was no leakage apparent in the valley below.

When building the new dam I had the foundation rock drilled with 2-in. drills from 10 to 15 ft. deep and from 15 to 20 ft. apart over the entire foundation. I did this for the purpose of testing the underlying strata. These holes were drilled under my personal supervision.

These holes were free of water at all times, except such as was poured into them by the driller to prevent the heating of the tool. These holes were drilled through the same strata of rock upon which the water back of the old dam was lying, and the bottom of the holes were from 60 to 65 ft. below the surface elevation of the water. If these strata had not been water-tight my conclusion was that any leakage from the old dam would have shown in these holes.

This seemed a logical conclusion then, and, upon explaining the condition to many well-informed engineers since, it has appeared to be logical to them.

The test holes sunk into the rock showed good solid strata of rock from 2 ft. to 4 ft. thick, with intervening strata of gravel and shale. These strata were so compact that they were almost as hard to drill through as the rock.

I want to correct some misstatements about how the dam was built. These misstatements have been made by those who did not witness its construction, but who have made an examination of the broken pieces of the dam since its demolition.

In preparing the foundation, care was taken to remove the thin strata of sandstone and shale until firm and thicker strata were exposed. The best evidence that this was actually done are the progress photographs, which distinctly show two things respecting this point. They show the foundation cleaned for concrete and the thickness of strata where the trench was cut out to build the cut-off wall. They also show great quantities of these top strata piled upon either side of the excavation. Most of these stones were removed to the crusher plant and broken up for concrete.

Every section of the foundation rock was carefully cleaned of all shale, gravel, or clay, and thoroughly washed and scrubbed down before any concrete was deposited upon it. Every large stone deposited in the concrete mass, to which any foreign substance adhered when it came from the quarry, was thoroughly cleaned and scrubbed. These large stones were carefully selected in the quarry after the blasts were made, and were stored in a separate place for the supervising engineer to inspect before they were lowered into the concrete.

There was a cut-off wall built throughout the entire length of

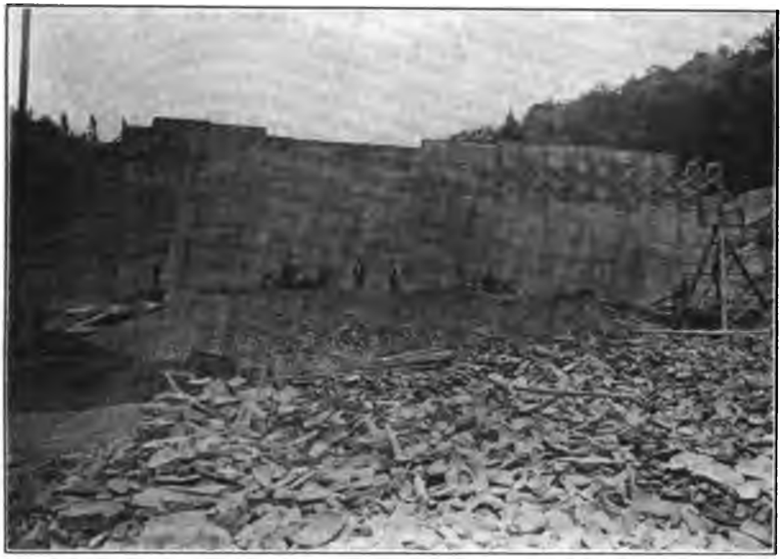


FIG. 1.
THE UPSTREAM FACE OF DAM. THE WASTE STONE IN THE FOREGROUND CAME FROM THE FOUNDATION.

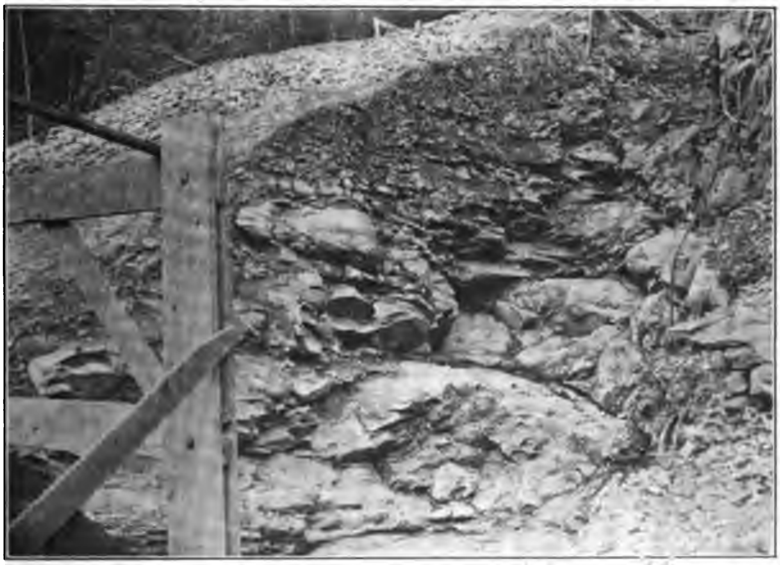


FIG. 2.
SHOWING THE CHARACTER OF THE ROCK IN THE FOUNDATION.

the dam. This wall was 4 ft. wide and from 4 to 2 ft. in depth. I looked upon it more in the nature of a key wall than a cut-off wall. All of it was built under the protest of the owner, who could not be convinced of its necessity.

Steel rods 1¼ in. in diameter and 25 ft. long, spaced 2 ft. 8 in. on center, were built into the dam vertically. These rods extended down into the rock foundation from 6 to 8 ft. and were secured by expansion nuts and cement mortar. It has been claimed that these rods were left out in many places. The best evidence that they were not are the progress photographs, which clearly show them across the entire dam.

The concrete used in the heavier portion of the wall was what is known as "cyclopean." The large stones were embedded in various ways, some as headers and some as stretchers; some on their greatest beds, and some on edge. Every large stone was surrounded with from 4 in. to 12 in. of concrete, which was deposited very wet and well spaded in.

The concrete mass consisted of one volume of Pennsylvania Portland cement, three parts of crushed sandstone dust and fine screenings, and six parts of crushed sandstone, the size of the stone corresponding to the run of the crusher up to two and one-half inch stones, with dust, screenings, and one-half inch stone eliminated. All the cement used was tested upon the work, a testing plant being maintained there. A boiling, setting, and tensile test was made of every carload, and no cement was accepted which gave evidence of being unsound, of too rapid setting, or whose tensile strength was below 200 lb. for twenty-four hours or 400 lb. for seven days, neat, or fell below 120 lb. after seven days old when mixed with three parts of the crushed stone dust we were using in the work.

The concrete was deposited in sections of 25 to 45 ft. in length of dam, the area of the section being governed by the amount of the concrete which could be deposited as a continuous operation. As each section was completed, keyways from 10 in. to 12 in. wide and deep were left in both the vertical and horizontal faces. Instead of leaving these keyways in all the horizontal surfaces, there were a few such surfaces where two rows of large stones were embedded in the surfaces so as to allow from 12 in. to 18 in. of their depths to project above the finished surface of the concrete. These formed a tie for the next section of concrete.

It has been stated that the concrete was not properly jointed and that keyways were not left. The best evidence of this is the progress photographs, in which the keyways and projecting stones are clearly shown.

Great stress has been laid upon the weakness of this dam by reason of the laitance in the joints. Of course I cannot positively state a condition which I did not personally see, but I can state as a fact, from personal observation, that I never saw fresh concrete deposited upon concrete which had been set up before the surface of the old concrete had been well watered and thoroughly swept down with wire street brooms. After which the entire surface was sprinkled with neat cement mortar upon which the very wet fresh concrete was deposited.

The supervising engineer had been employed by me for several years, and had supervised a great deal of concrete work. He knew my methods, and I had great confidence in him in having them carried out. I do not believe this confidence was misplaced in supervising this dam. If any laitance was found in the fractured joints of the demolished dam it was no doubt the neat cement which had been spread upon the surface of old concrete joints, and which had not combined with the fresh concrete. I have known such a result to happen under my own observation.

I have been building concrete for twenty-five years under all kinds of conditions. I have tested it in a laboratory maintained under my direction for several years, and I believe I know what good concrete is when I see it laid, and I think I can truthfully declare that I never had better concrete built for me than I had at the Austin dam.

Of course the sandstone rock, of which this concrete is composed, is not as strong a mass as granite or trap rock would be, but the mixture could not be better made. Every day's run was checked up by the engineer to see that the proper volume of cement was used, and we averaged, throughout the entire work, 1.25 barrels of cement to 1 cu. yd. of concrete. However, I believe an examination of the present pieces of concrete dam standing will show to any practical concrete expert familiar with the use

PLATE XI.
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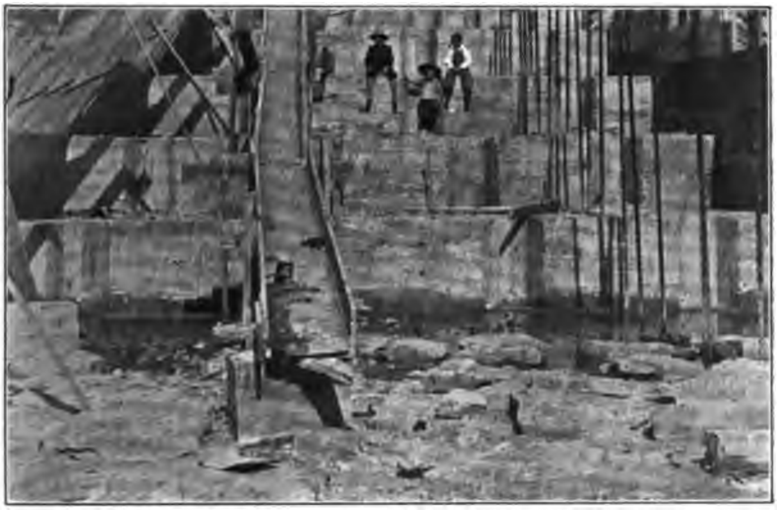

FIG. 1.
SHOWING THE VERTICAL KEYWAYS, AND LARGE STONES USED IN CONCRETE.

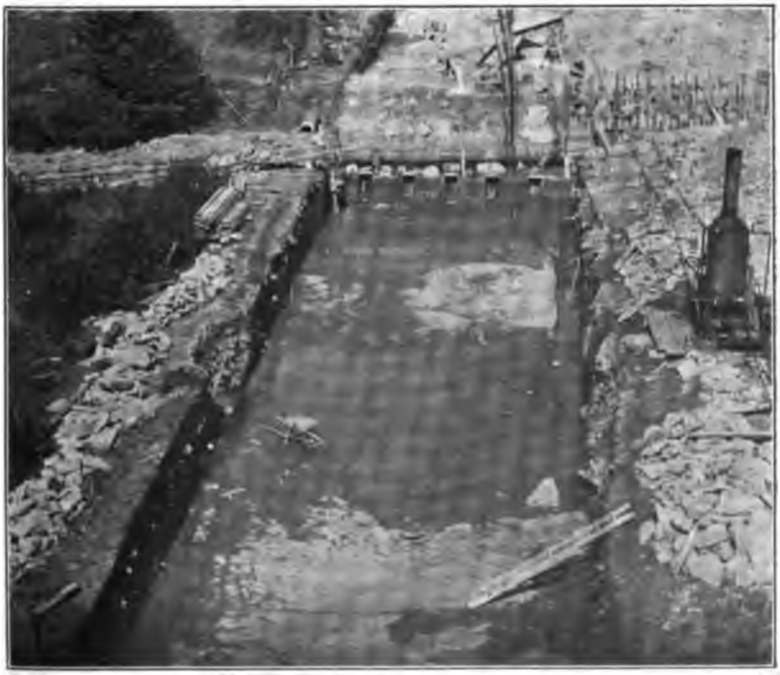

FIG. 2.
THIS VIEW SHOWS THE FOUNDATION UNDER THE SPILLWAY. THE TRENCH ON THE RIGHT HAS BEEN EXCAVATED FOR THE CUT-OFF WALL.

of this character of material, that the mixture in this dam was well made and laid.

In giving you the detailed description of the manner in which this dam was built, I am not trying to defend myself nor my supervising engineer, but to answer some of the unfair criticisms which have been made as to the quality of the work.

The failure of this dam was not the result of poor workmanship, but poor judgment upon my part in determining upon its foundation. I should have sought the advice of a man more skilled than I in determining foundations for dams. Had there been such a state officer it might have resulted in saving this dam and my reputation.

I was also too much influenced in my judgment by the necessity for keeping the expenditure within certain limits. I have since felt a very grave responsibility for my failure to advise my client early in my engagement that no paring down of this work should be countenanced. Had I done so, either the dam would not have been built, or it would have been built in accordance with my first design. The owner had no intention at any time of building a dam the safety of which he doubted, and no blame can be attached to him for its failure on January 23, 1910. He depended upon my judgment entirely, even though he may have tried to influence me to keep the expenditures down to the lowest possible limit.

To the young engineer who is called upon to design an important structure, the safety or sufficiency of which he is not entirely satisfied with, I would strongly urge the wisdom of calling to his help the advice of an older engineer especially skilled in that particular line. Never sacrifice safety for cost, no matter how urgent your client may become. He does not realize the danger, and you should. If you cannot agree with him, resign your engagement, for sooner or later the reckoning will come.

Now, just a word upon state supervision of dams. As previously stated in this paper, I think if a thoroughly competent state supervisor had been in office when this dam was designed it might never have failed, — but how are you going to get such a supervisor?

Since the failure of this dam, and its subsequent demolition, I have read every criticism from engineers which had come to my notice. For the most part, these criticisms have appeared in the several engineering journals and society reports, and I have compiled a little book containing these clippings. As I have been deeply interested in learning all I could about this matter, I have perhaps thus accumulated more evidence of the difference of opinion as to how to build a dam, as expressed by engineers in good standing, than others who have not had the same incentive. In view of this information, I want to say that it would take a pretty good examining board to pass upon the qualifications for a competent state dam supervisor.

In the discussion as to the proper method of reinforcing this dam after its failure in 1910, I have five different plans from as many engineers, and each plan based upon totally different principles.

For evidence that the profession is not a unit upon just how to build a dam to make it safe, and still keep within the economic limits of cost, you need only refer to the numerous dam failures both in this and in foreign countries. Their number far surpassess the number of failures of any other character of engineering structures.

DISCUSSION.

Mr. John C. Trautwine, Jr. It was about a year ago that the demolition of the Austin dam occurred, and shortly after that it was very actively considered by engineers. But, since then, many things have happened to engross our attention, and I came here entirely unprepared to have the matter brought to my recollection. I therefore regretfully allowed the paper to go by default, immediately after its reading, but it appears to me unfortunate that such should be the case, where the author has made so commendable a statement of his case, exonerating his associates, where this was possible, and frankly acknowledging the extent to which he considers himself at fault.

For myself, I have also to make a confession, of which I was reminded when Mr. Hatton referred to those who, with insufficient qualification, had expressed views with regard to the disaster, my confession being that I ventured to express a view without having seen the dam, either before or after its failure; but the case was very fully and clearly described and illustrated in our technical journals, and these accounts seemed to make it quite certain that the failure was due to the cause which Mr. Hatton has assigned, namely, not the sliding of the dam upon the upper rock stratum, but the sliding of the dam and the upper rock stratum as a whole upon a lubricated stratum below. That view, I must confess, I expressed, at the time; and I am glad to find it shared by Mr. Hatton.

STATE REGULATION OF PUBLIC UTILITIES.

BY MORRIS KNOWLES, C. E., PITTSBURGH, PA., AND BIRMINGHAM, ALA.

[*Read September 19, 1912.*]

In looking back through the proceedings of this Association, the writer finds that no paper has been previously presented upon the broad aspect of this important question. This may be due in part to the conservatism of the engineering profession with regard to the discussion of public questions. That conservatism, however, is passing, and President John A. Ockerson, of the American Society of Civil Engineers, outlined the new attitude of the profession in his address before the annual convention at Seattle, Wash., in June, 1912, in the following words:

> " There seems also to be a disposition to avoid participation in the discussion of public questions, even when closely related to the work of the profession. When congressional committees call on the Society for advice with regard to pending legislation, involving questions relating to engineering, it would seem to be a proper function of the Society to render such aid as may be practicable.
>
> " In fact, it might be well, under proper conditions, to go even further and use the influence the Society may have to mold public opinion along lines free from local or political bias, when our public works are the subject of discussion."

In the opinion of the writer, this counsel might even have been made somewhat broader. Such an organization as this can perform a real public service by discussing not only public works but public policies involving principles for the consideration of which engineers and works-managers are better equipped by training and habits of thought than almost any other class of citizens. In the political and social revolution which is now going on before our very eyes, many problems are involved, in the solution of which the scientific honesty, the accuracy of reasoning, the conception of economy and efficiency, possessed by trained technical men, should be of the highest value. In speaking to the students of Manchester University, June 28, 1912, on the social and political changes of Great Britain, Lord Morley said:

> " Before losing heart, let us be sure that our political arithmetic and algebra are right."

The language is significant as indicating the attitude of mind which he considered most valuable in the premises, and which is characteristic of men in the profession in which we are engaged.

Of all the problems involved in this present-day revolution, none is more clearly within the class that we have mentioned than that which we have as a subject to-day, " State Regulation of Public Utilities." Assuming prominence as it does at the time of the downfall of the political boss, the crumbling of the political machine, the growth of direct legislation, and the promise of return to truly representative government, it is but one of the many indications of the abandonment of the policy of *laissez faire* and competition, and of its replacement by a new public policy which places the liberty of the community before that of the individual, and recognizes that the natural resources, the tools of production, and the devices which man has invented for their economical utilization must be used, not for exploitation in the interest of any one or any group of individuals, but for rational and complete development, in such a way as to best conserve the welfare of this and future generations.

The growth of this new policy can be traced back through history to the edge of the Dark Ages. The Reformation and the Renaissance, often considered merely religious and intellectual movements, were in reality manifestations of the beginning of a world-wide demand for greater individual social and political liberty. The American and French revolutions, the general political disturbances throughout Europe about 1848, our own Civil War, and the Chinese Revolution, have been but local manifestations of the same universal demand. As a result, during the last century almost all governments in the civilized world have been made over to forms guaranteeing a greater measure of personal liberty.

The industrial development and the growth of city life that this revolution made possible, however, have brought about a realization that unlimited individual freedom is not an ideal state of society. Competition and *laissez faire* were well enough for the conquest of the forest and the desert. But as population increases and as economies become increasingly necessary, the unavoidable results of competition are increased control of raw materials and distribution, mass production, and combination. Equally inevitable results of the *laissez-faire* policy are exploitation and violation of community liberty in the interest of personal freedom. The last fifty years have therefore seen a new movement, manifested by legislation against trusts and against rebating, the public-health movement, the conservation of natural resources, — more latterly by the agitation of the newer doctrines of improvement of industrial and living conditions, regulation of public utilities, the regulation of all monopolistic business, direct legislation, state-insurance and minimum-wage legislation; and culminating in the present unprecedented interest and activity all over the world in the improvement of social and political conditions, that bids fair to reorganize society on a basis of the policy of social justice, even if it involves a restriction of hard-won individual liberty.

The basis of state regulation of industry is the fundamental common-law principle limiting the institution of private property itself. No man may use his property in a way opposed to the good of the community in which he lives, and which protects him in his possession of such property. A second principle, also inherited from the earliest days, is that he who devotes his private property to a public use thereby clothes it with public interest, which justifies not only great rights, but also public regulation. How far these principles are applicable to industry and business is to-day a burning question. We have heard the head of one great industrial combination declare publicly that the state should fix prices.

In a statement before the Stanley Committee at Washington, June 8, 1911, Judge Gary said:

" It seems to me possible that if there was a federal license law which enabled a corporation to apply to the government or a department of the government for a license to engage in interstate commerce business, then there could be considered and decided, first, all questions relating to the organization of the corporation itself; . . . and if it should be determined to issue a license, then one could be issued which might be revocable by the government, depending upon the conduct and management of the corporation — even relating to the question of prices, as to whether they were extortionate or not . . . or whether in any respect the conduct of the corporation was inimical to the best interests of the people generally. . . . Constructive legislation in this country is needed if we are to retain our position in the ranks of competing nations who are trying to make progress, and who are making progress."

Interesting as it would be, we cannot go into that subject here; nor can we inquire in great detail what uses of private property are public uses, and what industries are clothed with public interest. In various periods of history many different occupations have been considered subject to this principle. In medieval days the baker, the miller, the innkeeper, the barber, the tailor, the victualer, and the smith were required to supply all patrons on equal and customary terms. When physicians and surgeons were rare, they had to serve reasonably whoever called upon them. Later, with the development of towns, the ferryman, the wharfinger, and the carrier were held subject to public regulation. In the early days of the Massachusetts Colony, monopolies were granted to the trade guilds by the General Court and held to be public callings. Still later, the widest application has been given to the term at various times. Common carriers, water, gas, and electric companies, power companies, telephone and telegraph companies, warehouses and grain elevators, bridges, canals, ferries, waterways, draymen and hackmen, and many other lines of business have been held to be public callings. If we should go to the decisions of the courts with regard to what are public purposes, properly subject to government ownership, we find that libraries, theaters, hospitals, ferries, cemeteries, skating-rinks, musical entertainments, exhibitions of fireworks, employment offices, etc., have been included. In fact, the only test appears to be what the public good requires; and we may in future expect to see any business whatever in particular circumstances become regarded as a public calling and subject to regulation.

Interesting as this subject is, however, it has no part in this discussion, for the term "public utilities" has come to have a special restricted meaning, with but slight variation in different localities. This generally accepted meaning may be said to be well defined in a section in the public utility law presented to the General Court of Massachusetts at its last session. Omitting some of the legal phraseology it declared the term "public utilities" to include every individual company or corporation furnishing for public use any of the following services:

> "(*a*) The transportation or carriage of persons or property, or both, between points within this Commonwealth by railroads, railways, electric railroads, or steamships, including express service and car service carried on, upon, or rendered in connection with such railroads, railways, electric railroads, or steamships.
>
> "(*b*) The operation of all conveniences, appliances, facilities, or equipment utilized in connection with, or appertaining to, such transportation or carriage of persons or property, or such express service or car service, by whomsoever owned or by whomsoever provided, whether the service be common carriage or merely in facilitation of common carriage.
>
> "(*c*) The transmission of intelligence within this Commonwealth by electricity, by means of telephone lines or telegraph lines or any other method or system of communication, including the operation of all conveniences, appliances, instrumentalities, or equipment utilized in connection therewith or appertaining thereto.
>
> "(*d*) The production, utilization, sale, or distribution of gas, electricity, water, or energy for light, heat, fuel, or power within this Commonwealth, including the operation of all plants, conveniences, appliances, instrumentalities, facilities, or equipment utilized in connection therewith or appertaining thereto."

Even in the most individualistic times these services have been considered subject to public regulation and required to perform any duties laid upon them by statute. In addition they have been held to certain common law duties with regard to service and non-discrimination; and their rates have been regulated on the ground that they have no right to take a return on the unearned increment of their franchise value by charging what the traffic will bear. These duties have been briefly defined as follows:

1. To perform all duties required by statute.

2. (*a*) To serve all who apply.
(*b*) To provide safe and adequate service.
(*c*) To charge just and reasonable rates.
(*d*) To make no discriminations either in rates or in service.

It should be noted that these duties are all affirmative, differing in this respect from the negative obligation not to injure others by the use of property for private ends.

This is not the place to discuss the relative merits of municipal ownership and public regulation. Indeed, such a discussion would be entirely irrelevant to our subject, for, whether utilities are publicly or privately owned or operated, the need of broad regulation by the state or sovereign power is the same, and the methods and principles are identical. The duties of public utilities in the two cases are precisely similar. If the principles developed by countless decisions of courts and commissions are sound and just; if every applicant has the right to be served; if property should be so used in such services as to provide safe and adequate service; if discriminations are unjust and contrary to public policy; if depreciation ought to be allowed for; if it is unjust for taxpayers to contribute to lighten the burden of consumers, or for consumers to pay in rates any portion of general government expense, which ought in justice to fall on taxpayers, — then the regulation of public services is just as much the right and duty of the state in the one case as in the other. In its governmental functions the municipality is but the agent of the state; in its purely business enterprises it bears to the state the same relation as any other business corporation. Whether municipally owned public utility service be considered as belonging to either category, or as comprising functions in both, the grounds for state regulation are equally strong. This is a matter which should particularly interest the New England Water Works Association, as by far the larger majority of water works in New England are municipally owned.

Massachusetts, the first state going in for systematic public-utility regulation, recognized this principle in part and gave its Gas and Electric Light Commission the same authority in some matters over municipal plants as over private ones. The authority of the state boards of health of Massachusetts, New York, New Jersey, and other states, over quality of water, is without distinction regarding character of ownership. In England this stand has long been taken with regard to such features as accounting and reports. In at least one respect it has been carried further there than in any state in this country, for there, municipally owned and operated utilities pay a property tax into the general treasury, just as other property does. The basic theory of this appears to be that consumers ought not to be relieved of a portion of their burden at the expense of other taxpayers, by having exclusive tax-free use of property, which seems logical, if companies are to be similarly taxed, and just in the light of the general principles that have been heretofore explained. But it is inconsistent with the English policy of allowing some municipalities to make considerable profits, applicable to the reduction of the tax rate.

Wisconsin, leader in the modern development of public-utility regulation, makes no distinction whatever between publicly and privately owned plants, and requires the same standards in both cases, for quality, accounting, rates, financial management, reporting, depreciation accounts, etc.

Hon. John H. Roemer, chairman of the Railroad Commission of Wisconsin, said in an address before the Trans-Mississippi Commercial Congress at Kansas City in 1911, —

> '" The distinctive feature of the law, however, in Wisconsin is that of placing all municipal plants under the supervisory powers of the Commission to the same extent as privately owned plants. The wisdom of this policy is no longer disputable, for no greater benefit has been bestowed upon the public by regulation of public utilities than that resulting from the operation of the law upon municipal public utilities."

This may be opposed by some of the ardent supporters of local self-government; but local self-government does not mean a right to local mis-government. The rights of the citizen are just as much transgressed by a municipality which fails to fulfill its public utility duties as by a private corporation. As a matter of fact, regulation is sometimes even more necessary with a municipally owned plant than a private one; because people will often endure service and rates imposed upon them by their own town officers which would call forth vehement protest if a private company were involved.

Massachusetts was the pioneer in public utility regulation, and has always led the country in the regulation of municipal accounting and municipal finance, making the most minute regulations with regard to some details. Nevertheless, it is interesting to note that the public utility commission bill, presented to the General Court last winter (but not passed), held municipally operated plants subject only to the requirements of the sections on " Accidents," " Accounting," " Reports," " Appraisal," " Access and Inspection," and " Standards and Tests," and exempted them from orders by the Commission with regard to service, rates, or discriminations. The benefit to be derived from the law, which will doubtless be enacted in the future, will be greatly increased if this error is corrected.

Recognizing, then, the benefit of regulation in all cases, let us discuss briefly the methods and principles that are to be followed. Regulation by special legislation or by court decisions have been proposed as sufficient by some, but neither expedient can be supported. With regard to the former, Justice Timilin of the Wisconsin Supreme Court in deciding one of the few cases, perhaps the only case, that has been appealed from the decree of the Wisconsin Railroad Commission, said,

> " It is argued that the power to fix rates is a legislative one and can never be anything else; . . . that the legislative power is by the Constitution vested in the Senate and Assembly, and cannot be set apart except as expressly provided for in the Constitution; but when we add to this that, because of the multitude of detail, the intricacy of the subject, the expert knowledge required, the numerous separate investigations of inter-related questions of fact which are necessary . . . a legislative body . . . would find it an actual rather than a legal impossibility to fix just and reasonable rates, it becomes apparent that this position tends to the conclusion that the state . . . was shorn of some of its usual and necessary power of sovereignty and became impotent to exercise the power of regulation. Regulation by direct action of the legislature has been tried and found impracticable and its attempt generally abandoned."

The same reasoning applies equally well to regulation by municipal ordinance. It would demonstrate the uselessness of this method of regulation, even if local prejudices, local politics, and high feeling did not commonly make impossible the unbiased, judicial attitude which is the *sine qua non* of reasonable regulation.

Equally unsatisfactory is regulation by court decision. All over the country such tribunals are already overburdened with work, and action would often be delayed beyond the time where it would be of value. Moreover, the work requires more than a judicial mind. Engineering, financial, and business judgment must be possessed from actual experience, or understood from long consideration of such matters, to a degree that is usually impossible for the judge. Finally, court decisions must necessarily be, in general, corrective rather than preventive, and hence such regulation is contrary to our present-day ideas of governmental efficiency.

To change two words in the message of President Taft, advocating the establishment of a commission to investigate industrial strife, —

> "At the moment when discomforts and dangers incident to *utilities service* are actually felt by the public there is usually an outcry for the establishment of some tribunal for the immediate settlement of the particular dispute, but what is needed is some system, devised by deliberate study in advance, that will meet these constantly occurring and clearly foreseeable emergencies, — not a makeshift to tide over an existing crisis. Not in a rainstorm but in fair weather should the leaking roof be examined and repaired."

A priori consideration would therefore lead us to the conclusion that a permanent commission is the correct solution of the problem, and experience has justified this conclusion. Massachusetts, Wisconsin, New York, Vermont, New Jersey, New Hampshire, Kansas, Oregon, Ohio, Washington, Connecticut, California, Maryland, Oklahoma, and many other states have legislation placing some or all public utilities under the jurisdiction of one or more commissions. The national experience with the Interstate Commerce Commission has borne splendid testimony to this method of regulation.

Opinion is practically uniform in the desirability of commission regulation; but there is still discussion as to whether utilities should be supervised by municipal or state commissions. In the writer's opinion municipal regulation alone will never be satisfactory. For municipally owned utilities such regulation is out of the question. The community of interest in making a good showing and the lack of perspective may often defeat the purpose. In the case of privately owned companies, the pressure of local prejudice and feeling makes difficult the preservation of the judicial frame of mind and spirit of fairness which are indispensable. In the case of a few large cities, high-grade city commissions have been partially successful. But even in these cases cities cannot afford expert service as extensive or of as high grade as is available when they act together through a state commission; and such local commissions have not an equal opportunity to gain such varied experience or to accumulate so large an amount of data that may be applicable to future investigations and decisions. Moreover, the intercorporate relations of most public utilities make effective local regulation as impossible in many cases as would be the regulation of interstate commerce by a state railroad commission. It is believed, therefore, that a single state commission with ample powers and conspicuous responsibility will be most satisfactory. This does not mean that in the largest cities local commissions cannot be of great value in investigating local conditions in greater detail, and in collecting local information; but even if they do exist, a state commission is just as necessary to supplement them, and to secure in their work uniformity, equality, and efficiency.

An objection often urged against any state-wide measure of this kind is that it means the domination of the cities by country districts and the "farmer vote." In matters of fundamental progress, however, the interests of city and country are one and the same; and apparent opposition often terminates in mutual benefit. You will recall an example of this at the time when the Metropolitan Water District of Boston undertook to condemn additional drainage areas in Massachusetts. The protest of the country districts resulted in an act by the General Court of 1907, requiring that all cities and towns in the Metropolitan Water

District "shall, after December 31, 1907, equip with water meters all water services thereafter installed for them, and shall also annually equip with water meters five per cent. of the water services which were unmetered on December 31, 1907." The effect has been to reduce the waste, to prolong the life of the works then existing, and to postpone the expenditure of great sums for extensions.

A further criticism of the commission idea is that the machinery may readily come under the control of a few bad men. No system can take the place of good men in public life. But experience has shown that when large responsibility is conspicuously centered on a few men, with full publicity regarding their proceedings, such fears are usually groundless. The recent tendency toward the commission form of municipal government is based on the same principle.

To quote again from Justice Timilin, in deciding a case appealed from the Wisconsin Railroad Commission, —

> "Experience tends to show that public officers, as well as private citizens, are apt to rise in character and dignity to meet responsibility, but to shift a responsibility where opportunity of shifting is easily afforded, and thereby to deteriorate in efficiency and in character."

In most communities, appointment of members to the State Public Utility Commission is the most satisfactory method of selection. Appointees should be men of wisdom, deliberation, scientific honesty, judicial temperament, breadth of view, and public spirit, with wide knowledge and experience in business, finance, economics, and public service. Engineering and legal training are best adapted to secure some of these characteristics; but the qualifications mentioned are more essential than such a detail as professional training, and technical service can be secured by the employment of experts. The importance of the benefits accruing to the public justifies ample salaries so as to secure the services of the ablest men. Full power should be given to such a commission to investigate accidents, rates, and service; to make valuations; to require uniform accounts and uniform reports, and control issue of securities and financial management; to require proper allowance for depreciation; to examine accounts and inspect property; and to make and enforce orders regarding rates, standards, service, and discrimination. Full publicity in all matters is desirable. Future experience will show whether or not it is advisable to include provision for a modified form of the recall, such as is the novel feature of the Connecticut law.

It is still too early to form a final opinion regarding the results of thorough-going regulation of the Wisconsin type; but the tendency toward better service, better feeling between the utilities and the public, more equitable rates, greater stability of securities, and disappearance of discrimination and of corruption of local politics by franchise-seeking companies is unmistakable.

This is a subject of great and growing importance, and one which will in the immediate future come up for legislation in many of the states that have not already taken care of it. The members of this Association, and the Association, are in a position to make a public contribution of great value by taking an active interest in the consideration and development of such legislation, throughout the states in which the membership is active.

DISCUSSION.

Mr. F. Herbert Snow.[*] Mr. President, I live in a commonwealth where the need of state and national control of public utilities is felt. The control of floods and the conservation of the water resources has to do at one end of the matter with the individual ownership of land and riparian rights, while at the other end it has to deal with affairs involving state rights and the national control.

One of the hopeful signs of the times is the taking out, by common consent, from petty politics of affairs having such extended scope. A large project may be rendered impracticable of accomplishment because of petty hindrances at the roots, where the individual (protected in his rights by laws obscure as to meaning through the practice of the courts varying in different jurisdictions and states) may by wrong political methods direct sentiment in channels to obtain what appears to be the protection of the common interests when, to the contrary, the public benefits are lessened and the development of resources for the common good is prevented.

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[*] Chief Engineer, Pennsylvania Department of Health.

Some very good projects that should have been municipally owned have been permitted to pass into the hands of private ownership because of despair as to ever making the improvement properly, or of maintaining the improvement thereafter satisfactorily, under municipal control. Again, the opposite has been true. The better citizens of the community were opposed to the passing into the hands of capitalists of the public utility; but through political manipulation public control was lost and the citizens of such communities feel, whether it be justly or unjustly founded, that they are in the hands and grasp of a monopoly.

Speaking with respect to small water-works systems, my observation has been that it is easier and more satisfactory to control a water-works system owned by private capital than to handle and control municipally owned water works. In the former case, the law is less cumbersome and punishment can be inflicted more readily and promptly, while in the latter case there are many obstacles to the successful administration of the law.

Politics cannot be eliminated from public affairs, but they can be toned up considerably. The time has come when reputable citizens of a community should no longer hold aloof from participation in practical politics. If men would stop criticising the conduct of public affairs and instead would participate actively in politics, the result at once would be the fairer and more intelligent discussion of public matters, and more rapid progress in the distribution of benefits where they belong, among the people, would accrue.

Undoubtedly many of you have observed how easy public sentiment can be aroused against the management of privately owned water works. However, capitalists have securities to protect and they must be financially responsible to be worthy of public confidence so far as investments are concerned. If the revenues are not sufficient, bankruptcy follows. With a municipally owned plant deficits can be made up out of general taxation.

The public treasury is a safeguard, and so it is more feasible to do things in connection with a municipally owned system than with a privately owned system.

In New England, where most of the water works are owned by the municipality, the necessity for state regulation and control of the water-works system may not be felt as keenly as in a state where the works are largely owned and operated by capitalists. I believe that the regulation of public utilities should embrace the water-works system regardless of ownership, whether it be a municipal corporation, a private corporation or individual, if the regulation is to take in water works at all.

When we come to the matter of dams and storage reservoirs on streams as a part of the development of the water resources of a district, it is apparent that a great resource like water should not be developed over any extended area except for the benefit of all concerned. It is too true that a few individuals, under the advice of skilled attorneys learned in law, can hold up the development of this great resource until the benefits are directed into the desired channels where a few will profit more in proportion to their interests than will the public.

Conservation and utilization of water resources is a profound subject. It calls for more comprehensive laws and a change in the practice or administration of law. There is such a wide range in the application of legislation affecting rights, that hardly anybody seems to know what to depend upon. The practical result of it all to-day is a great hindrance to the enrichment of the people through the development of this resource. A short cut to proper development of water power and water wealth may be found in state and national control of public utilities dealing in water. It is possible, beginning in the district or the county and extending to the state and national control, to bring all under some practical plan of coöperation. I do not see clearly now how it can be done at this moment; but I believe in the proposition and that it will be worked out. I would not hesitate, were the responsibility placed upon me, to undertake the solution of the problem. Furthermore, I know of other students and men engaged in rubbing up daily against these problems in a minor way, who are inspired with confidence that a solution of the great problem will be reached along lines under which the interests of the public will be subserved.

Finally, one will not read of failure of dams and the devastation of communities in the valley below, after it has become impossible for any one to build a dam and maintain a reservoir except under the responsible supervision of a competent engineer.

I have labored in my state of Pennsylvania for an organization and unification of engineers, not for the purpose of promulgating trade unionism standards, but for the greater and higher benefit of organization along professional lines. I would make it compulsory on all public works in towns, counties, and state, for a certified engineer to be employed. I would not prohibit the individual from employing whomsoever he might choose up to a certain extent; but I would not permit any incompetent man to have responsible charge of structures or facilities having to do with and involving the safety and lives and the health of the people. It is all right to have the public utility commission and state or central control of public utilities, but without the fixing by statute of the relation between the public and the engineer and without licensure or control to a certain extent of the practice of civil engineering in connection with public utilities, any public utility commission will find itself greatly handicapped in bringing about the greatest good to the greatest number of people.

Believing as I do that I will soon see organization and unification of members of the engineering profession, and that affairs relating to public utilities will by general and common consent be placed under central control, state and national, and that furthermore the people of this land are rapidly coming into their intelligent possession of it through the separation of many practical matters that have no real political significance, but that have up to the present time been prominent considerations in dominating the political parties, I can conclude this rambling discussion by holding up for contemplation a most optimistic view. May we all live and help to make it a speedy consummation!

PROCEEDINGS.

BUZZARDS BAY, June 26, 1912.

The June meeting of the New England Water Works Association was held at Buzzards Bay, Mass., on June 26, 1912.

The following members and guests were present:

MEMBERS.

J. M. Anderson, F. E. Appleton, C. H. Baldwin, L. M. Bancroft, G. W. Batchelder, J. W. Blackmer, E. C. Brooks, James Burnie, T. J. Carmody, J. C. Chase, J. H. Child, R. C. P. Coggeshall, W. R. Conard, G. E. Crowell, A. W. Cuddeback, F. W. Dean, J. C. DeMello, Jr., A. O. Doane, G. F. Evans, E. D. Eldredge, G. H. Finneran, A. N. French, A. S. Glover, Clarence Goldsmith, X. H. Goodnough, J. C. Hammond, Jr., L. M. Hastings, D. A. Heffernan, C. E. Johnson, Willard Kent, G. A. King, J. J. Kirkpatrick, C. A. Leary, T. J. Lynch, T. J. MacCarthy, F. A. McInnes, T. H. McKenzie, C. T. Main, John Mayo, G. F. Merrill, J. W. Moran, A. S. Negus, G. A. Nelson, F. L. Northrop, J. K. Nye, H. E. Perry, E. B. Phelps, W. H. Pitman, L. C. Robinson, A. L. Sawyer, W. E. Smith, G. H. Snell, R. L. Tarr, C. N. Taylor, D. N. Tower, Percy Warren, L. R. Washburn, W. J. Wetherbee, J. C. Whitney, L. J. Wilber, F. B. Wilkins, G. E. Winslow. — 62.

ASSOCIATES.

Harold L. Bond Company, by Geo. S. Hedge; Builders Iron Foundry, by A. B. Coulters; Goulds Manufacturing Company, by R. E. Hall; Hersey Manufacturing Company, by A. S. Glover, H. D. Winton; H. Mueller Manufacturing Company, by G. A. Caldwell; Millar & Son Company, by C. F. Glavin; National Meter Company, by C. H. Baldwin, J. G. Lufkin; Norwood Engineering Company, by C. E. Childs; Pittsburg Meter Company, by B. A. Lester; Rensselaer Valve Company, by C. L. Brown, F. S. Bates; Ross Valve Manufacturing Company, by C. W. Ross; A. P. Smith Manufacturing Company, by D. F. O'Brien, T. F. Halpin, F. L. Northrop; Standard Cast Iron Pipe and Foundry Company, by W. F. Woodburn; Thomson Meter Company, by E. M. Shedd; United States Cast Iron Pipe and Foundry Company, by D. B. Stokes; Water Works Equipment Company, by W. H. Van Winkle; R. D. Wood & Co., by C. R. Wood; Henry R. Worthington, by Samuel Harrison. — 23.

GUESTS.

Arthur Howland, F. M. Miner, Mrs. E. B. Phelps, Col. C. P. Nutter, W. H. Bacon, S. M. Spencer, A. W. Parker, Miss J. M. Ham, of Boston; Mrs. T. J. Carmody, Miss M. Mann, Miss C. Sullivan, Miss H. Hanley, of Holyoke; Mrs. Geo. E. Winslow, Miss Myra Winslow, Mr. C. H. Mann, of Waltham; Mrs. G. H. Snell, Mrs. Frank Hunnewell, Miss Bertha Hunnewell, of Attleboro; E. W. Hall, West Acton; S. P. Hurd, Swampscott; H. S. Howe, Concord, F. B. Wilkins, Milford, N. H.; Mrs. E. C. Brooks, Cambridge; N. B. Tower, Cohasset; T. Appleton, Chelsea; G. E. Hildreth, Manchester; W. H. Larcom, Beverly; Mrs. L. M. Bancroft, Reading; W. M. Foster, Nashua, N. H.; C. F. Goodnough, Brookline; Raymond Allen, Manchester; John Ayer, Newton Highlands; H. R. Draper, Ayer; Mr. A. S. Ackerman, Mr. Waring, of Cape Cod; F. E. Smith, N. Andover; W. Whittemore, Weston; F. L. Branham, Lowell; C. E. Shattuck, Wellesley; W. J. Turnbull, State Farm; Master Edward H. Eldredge, Onset; Mrs. L. J. Wilber, Brockton; Charles S. Ashley, W. F. Williams, F. H. Taber, F. P. Washburn, C. H. Gifford, New Bedford, Mass. — 48.

The Secretary read applications for membership, duly approved, from: F. C. Beck, treasurer St. Johnsbury Aqueduct Company, St. Johnsbury, Vt.; G. A. Benjamin, manager Castine Water Company, Castine, Me.; J. T. Bowles, physiologist, Canal Zone, Cristobal, C. Z.; J. W. M. Bunker, instructor in sanitary analysis, Harvard University, Cambridge, Mass.; W. M. Davis, city engineer, Prince Rupert, B. C.; E. J. Fossas, student, 524 West 124th Street, New York, N. Y.; G. W. Hubbard, superintendent water works and light plant, Elberton, Ga.; J. J. Mack, 14 Barr Street, Salem, Mass.; J. H. Mendell, superintendent water works, Manchester, N. H.; R. H. Stearns, designing engineer, Board of Water Commissioners, Hartford, Conn.; F. P. Washburn, New Bedford Water Board, New Bedford, Mass.; M. C. Whipple, instructor in sanitary chemistry, Harvard University, Cambridge, Mass.

The Secretary was directed to cast one ballot in favor of the applicants, and he having done so they were declared duly elected members of the Association.

THE THIRTY-FIRST ANNUAL CONVENTION.

WASHINGTON, D. C.,
September 18, 19, 20, 1912.

The thirty-first annual convention of the New England Water Works Association was held at Washington, D. C., September 18, 19, and 20, 1912.

The official headquarters of the Association were at the Congress Hall Hotel, where the sessions of the convention were held and the associate members displayed their exhibits.

The following-named members and guests were in attendance:

HONORARY MEMBER.

F. W. Shepperd. — 1.

MEMBERS.

S. A. Agnew, E. R. B. Allardice, K. Allen, Dr. J. A. Amyot, J. M. Anderson, M. N. Baker, C. H. Baldwin, A. F. Ballou, L. M. Bancroft, F. A. Barbour, Edward Bartow, G. B. Bassett, G. W. Batchelder, G. A. Benjamin, C. R. Bettes, Philander Betts, F. E. Bisbee, A. E. Blackmer, J. W. Blackmer, C. A. Bogardus, James Burnie, T. J. Carmody, C. E. Chandler, E. S. Cole, W. R. Conard, J. H. Cook, H. R. Cooper, L. S. Doten, H. P. Eddy, E. D. Eldredge, F. L. Fuller, A. S. Glover, W. B. Goentner, J. M. Goodell, F. E. Hall, Paul Hansen, R. J. Harding, W. C. Hawley, F. S. Hollis, W. C. Hooper, J. L. Hyde, D. D. Jackson, G. G. Kennedy, E. W. Kent, Willard Kent, J. A. Kienle, G. A. King, J. J. Kirkpatrick, F. W. Green, Morris Knowles, B. C. Little, J. B. Longley, T. J. Lynch, Daniel MacDonald, T. H. McKenzie, H. B. Machen, John Mayo, G. F. Merrill, William Murdoch, J. A. Newlands, F. L. Northrop, E. L. Nuebling, T. A. Peirce, A. E. Pickup, W. H. C. Ramsey, J. F. Reagan, Jr., A. A. Reimer, C. H. Ross, H. F. Salmonde, P. R. Sanders, Henry W. Sanderson, J. E. Sheldon, G. H. Snell, J. F. Sprenkel, G. A. Stacy, G. T. Staples, Sydney Smith, J. A. Tilden, J. C. Trautwine, Jr., A. E. Walden, J. H. Walsh, R. S. Weston, G. C. Whipple, L. J. Wilber, G. E. Winslow, I. S. Wood, Walter Wood, Timothy Woodruff. — 88.

ASSOCIATES.

T. D. Bausher; N. S. Sammis and A. B. Coulters, of Builders' Iron Foundry; R. W. Conrow, Central Foundry Company; F. H. Coffin, F. H. Coffin & Co.; C. J. Fay, Coffin Valve Company; J. L. Hough, Darling Pump and Manufacturing Company; C. A. Vaughan and P. H. Williams, Gamon Meter Company; A. F. Fisher, Glauber Brass Manufacturing Company; C. Mueller and H. S. Piper, Hays Manufacturing Company; J. A. Tilden, W. C. Sherwood, A. S. Glover, H. C. Erwin, Jr., and E. J. McKee, Hersey Manufacturing Company; T. E. Dwyer, Lead Lined Iron Pipe Company; H. F. Gould, Ludlow Valve Manufacturing Company; C. F. Glavin, Charles Millar & Son Co.; G. A. Caldwell, F. B. Mueller, and C. F. Ford, H. Mueller Manufacturing Company; C. H. Baldwin and J. G. Lufkin, National Meter Company; H. B. Hodgman, National Water Main Cleaning Company; T. D. Faulks, Neptune Meter Company; H. W. Hosford, Norwood Engineering Company; J. B. Turner, T. C. Clifford and V. E. Arnold, Pittsburgh Meter Company; C. L. Brown, Rensselaer Valve Company; William Ross, Ross Valve Manufacturing Company; H. F. Halpin and J. Strackbein, A. P. Smith Manufacturing Company; E. M. Shedd, S. D. Higley, and J. H. Atwell, Thomson Meter Company; L. P. Anderson, Union Water Meter Company; D. B. Stokes, United States Cast Iron Pipe and Foundry Company; W. H. Van Winkle, Water Works Equipment Company; C. R. Wood and H. S. Simons, R. D. Wood & Co.; J. A. Port and Samuel Harrison, Henry R. Worthington; E. F. Bart, National Tube Company; W. F. Woodburn, Standard Cast Iron Pipe and Foundry Company. — 47.

GUESTS.

Clinton L. Bancroft, Wakefield, Mass.; Mrs. Samuel Harrison, Boston, Mass.; Mrs. F. M. Eayrs, Nashua, N. H.; Miss Ida Flagg, Philadelphia, Pa.; Master Neddie Eldredge, Onset, Mass.; Mrs. C. A. Vaughan, Newark, N. J.; Mrs. George E. Winslow, Waltham, Mass.; Miss Mary Wales Glover, Newton, Mass.; Mrs. Geo. T. Staples, Miss Florence S. Staples, and Miss Grace M. Staples, Dedham, Mass.; Mrs. Geo. A. King, Taunton, Mass.; Miss Margaret Hawley, Wilkinsburg, Pa.; Mrs. John Mayo, Bridgewater, Mass., Mrs. George A. Caldwell, Boston, Mass.; F. P. Hellev, Mrs. F. P. Hellev; and A. E. Leinbach, Reading, Pa.; Mrs. H. N. Hosford, Florence, Mass.; Mrs. L. J. Wilbur, Brockton, Mass.; Mrs. George H. Snell, Attleboro, Mass.; Miss Edith M. States, Attleboro, Mass.; Mrs. John H. Cook, Passaic, N. J.; Mrs. F. L. Fuller, Wellesley, Mass.; Mrs. R. J. Harding, Poughkeepsie, N. Y.; Robert W. Grout, Woonsocket, R. I.; Mrs. F. W. Shepperd, New York; Mrs. T. F. Halpin and Miss Mary Smith, Newark, N. J.; L. D. Conklin, Bethlehem, Pa.; A. R. McKlin, Albany, N. Y.; Mrs. James Burnie and Miss Helen M. Burnie, Biddeford, Me.; Mrs. N. R. Cooper, Thompsonville, Conn.; Geo. C. More and Mrs. Geo. C. More, Middletown, Conn.; J. P. Newman, New York City; J. S. Biszby, Moorestown, N. J.; Mrs. W. B. Goentner, New York; S. C. Mackley, Roanoke, Va.; L. M. Hills, Mrs. L. M. Hills, and Mrs. E. R. B. Allardice, Clinton, Mass.; A. W. Warner, Philadelphia, Pa.; Mrs. E. W. Kent, Newport, R. I.; W. H. V. Reimer, Mrs. W. H. V. Reimer, and Miss I. A. Reimer, East Orange, N. J.; James L. Wilde, Washington, D. C.; James P. Bacon, Arlington, Mass.; William H. Larcom, Beverly, Mass.; Mrs. C. E. Chandler, Norwich, Conn.; Mrs. George A. Stacy, Marlboro, Mass.; Willard S. Isham, Washington, D. C.; May I. Agnew, Brooklyn, N. Y.; Mrs. Irving S. Wood, Providence, R. I.; Mrs. T. A. Pierce and Mrs. Emma A. Vaughan, East Greenwich, R. I.; Edgar J. Buttenheim, *The American City*, New York; Henry Gannett, Washington, D. C.; Farley Gannett, Harrisburg, Pa.; Mrs. George A. Benjamin, Castine, Me.; W. F. Disney, Rockville, Md.; Agnes C. Babb, Augusta, Me.; Adam Ross, 2d, Troy, N. Y.; Phillip P. Wells, Washington, D. C.; F. J. Wise, Pittsfield, Mass.; William McSweeney, Boston, Mass.; Mrs. Willard Kent, Narragansett Pier, R. I.; William T. Wells, Washington, D. C.; Andrew E. Barrett, Lowell, Mass.; Mrs. Thomas J. Carmody, Miss Elizabeth Lynch, Miss Maria Maria, and Mrs. Walter Hanley, Holyoke, Mass.; Edward K. Otis, Worcester, Mass.; H. C. Hatton, Wilmington, Del.; W. J. Dodge, Chattanooga, Tenn.; A. Clinton Decker, Birmingham, Ala.; R. L. Clemmitt and Miss Frances E. Allen, Baltimore, Md.; H. D. Yat, Washington, D. C.; Fred W. Schultz, New York; Miss Joan M. Ham, Boston, Mass. — 85.

WEDNESDAY, SEPTEMBER 18, MORNING SESSION.

The convention was called to order at 10.30 A.M. by George W. Batchelder, the President, who said:

Ladies and Gentlemen of the New England Water Works Association, — I trust that the convention which opens this morning will be a source of profit and enjoyment to you all. We are meeting many miles away from our headquarters in Boston, and, lest we should feel like strangers in a strange land, a distinguished gentleman has consented to speak words of welcome to us. I take pleasure in presenting to you at this time Col. William V. Judson, engineer commissioner of the District of Columbia.

COLONEL JUDSON. *Gentlemen*, It is a great privilege to supply communities with a product against which there is no prejudice — to use which liberally is not to be extravagant but to insure health and cleanliness.

In introducing so many springs of limpid water into the dwellings of men you are doing or facilitating the things that most differentiate the life of civilized man from the life of the savage.

From the modern scheme of things you could be spared least of all.

If communities depend upon you for the exercise of so all-important a function, your responsibility is great indeed. The satisfied purveyor of water that carries to people the germs of disease and death merits the punishment awarded to the homicide.

I know some of your worries. Especially at the present time, when we have just raised our water rates, am I brought to realize the extreme reluctance people exhibit to pay a fair price for water.

Gentlemen, in behalf of the District Commissioners I welcome you to Washington. I hope you will forget worries of all kinds and enjoy your stay with us.

THE PRESIDENT. Colonel Judson, in behalf of the Association, I wish to thank you for your cordial and hearty words of welcome. I am sorry that you have so much trouble on your mind, but you don't show it a great deal, and I think you will pull through. We would like very much to have you stay with us as long as you find it convenient, at the meeting to-day or at any future meetings while we are in your city. We expect to go away with pleasant recollections of Washington, and we may come back again at some future time.

The Secretary read the following names of applicants for membership, all of whom had been properly endorsed and approved by the Executive Committee:

Active: Daniel Francis McCarthy, city engineer and superintendent of streets, sewers, and water works, St. Albans, Vt.; George Neut, chief engineer of water works, Santiago, Chili; Charles R. Harris, Portland, Me., bookkeeper Portland Water Company; Langdon Pearse, Chicago, Ill., division engineer, Sewage Disposal Investigations, Sanitary District of Chicago; A. S. Malcomson, Freeport, N. Y., general manager of the Hempstead and Oyster Bay Water Company of Merrick, Long Island.

Associate: Thomas D. Bausher, Reading, Pa., inventor and maker of kindling and fuel, water works and plumbers' furnaces, thawing furnaces for frozen earth, heating furnaces for orchards, icy sidewalks, and other devices; National Tube Company, Pittsburgh, Pa., manufacturer of pipe fittings, valves, seamless tubing, etc.

On motion of Mr. Frank L. Fuller, the Secretary was empowered to cast the ballot of the Association in favor of the candidates, and, he having done so, they were declared by the President duly elected members of the Association.

The Secretary read the following reports of committees:

SEPTEMBER 14, 1912.

Mr. WILLARD KENT,
Secretary New England Water Works Association,
715 TREMONT TEMPLE, BOSTON, MASS.

Dear Sir, — The Committee on Yield of Drainage Areas is unable to make a final report at this time. The returns covering the dry period, which in some places extended from June, 1908, to February, 1912, have been received from twelve drainage areas, five located in Massachusetts, one in New Hampshire, two in Connecticut, and four in the easterly portion of New York.

Extended computations and comparisons have been made relating to these drainage areas, which show that the investigation will throw much light on the safe yield from streams in different locations with varying quantities of storage. The material already available is sufficient for a report, but it is expected that more returns will be received before our final report is made. We hope to present this final report at the annual meeting in January.

Very truly yours,
FREDERIC P. STEARNS, *Chairman.*
H. H. BARROWS, *Secretary.*

AUGUST 16, 1912.

Mr. WILLARD KENT,
Secretary N. E. W. W. Ass'n,
715 TREMONT TEMPLE, BOSTON.

Dear Sir, — I beg to report for the Committee on "Standard Form of Specifications for Cast-Iron Water Pipe and Special Castings" that no meetings have yet been held, the work done up to date being confined entirely to individual consideration of the subject.

Respectfully,
F. A. MCINNES, *Chairman.*

BOSTON, MASS., August 14, 1912.

WILLARD KENT, *Secretary,*
NEW ENGLAND WATER WORKS ASSOCIATION,
715 TREMONT TEMPLE, BOSTON, MASS.

Dear Sir, — About the time your letter was received negotiations were under way with the hydrant manufacturers for sample hydrants for test for the information of the committee in connection with the hydrant specifications, which are still under consideration, and we held your letter thinking that a little later we might be able to know definitely just when the tests would be made.

We are pleased to say that arrangements have been completed for the hydrants, and we expect that these will be shipped to the testing ground within the next week or two. This, however, will not be in time to permit the tests to be completed and the committee to reach final conclusions regarding the specifications before the September convention of the Association, and it will, therefore, be necessary to delay report until a later meeting.

Yours truly,
H. O. LACOUNT, *Chairman.*

To the Members of the New England Water Works Association, — Your Committee on Water Consumption Records and Statistics regrets its inability to make final report at this time, and asks to be continued.

Substantial progress has been made in collecting data of value concerning water consumption, in different cities in New England, and under different conditions. Your committee is now working these data up, and is considering the most desirable revision of the form now used by the Association for collecting statistics annually from the various water works and departments represented by the members of this Association.

Respectfully submitted,
LEONARD METCALF, *Chairman.*

The President announced that the reports, being merely reports of progress, did not require any action on the part of the meeting. The next business was the appointment of a committee to nominate officers for the ensuing year. Mr. George A. Stacy moved that a nominating committee of five be appointed by the chair. The motion was adopted. The President subsequently appointed the following committee: John C. Whitney, Frank A. Barbour, Arthur F. Ballou, Frederick W. Gow, and Robert J. Thomas.

The first paper on the program was on "State Control of the Design and Construction of Dams and Reservoirs; Actual Practice in Eastern Connecticut," by Charles E. Chandler, C.E., Norwich, Conn. The President called upon the following-named gentlemen to discuss the paper: Mr. P. P. Wells, chief law officer of the Interior Department; Prof. Philander Betts, member of the New Jersey Public Utilities Commission; and Mr. Alex Rice McKim, inspector of dams and docks, State Conservation Commission, Albany, N. Y. Mr. Theodore H. McKenzie, C.E., member of the Connecticut State Board of Health, and secretary and treasurer of the Terryville Water Company, Southington, Conn., also contributed a written discussion of the paper.

Mr. Cyrus C. Babb, chief engineer Water Storage Commission of Maine, Augusta, Me., read a paper entitled "Certain Legal Aspects of Water Power Development in Maine." Mr. Morris

Knowles, C.E., director Department of Sanitary Engineering, University of Pittsburgh, Pa., followed with a written discussion of the paper, which was also discussed by Mr. P. P. Wells, Professor Betts, and Mr. Arthur A. Reimer, engineer Water Department, East Orange, N. J.

A paper on " State Control of Dams in Pennsylvania," by Prof. Frank P. McKibben, of Lehigh University, South Bethlehem, Pa., was read by Mr. Leon D. Conkling, and was discussed by Mr. John C. Trautwine, Jr.

Thursday, September 19, Morning Session.

At the opening of the session on Thursday morning, Mr. T. Chalkley Hatton, the designer of the dam at Austin, Pa., read a paper presenting some features of the construction and subsequent failure of the work; and Mr. John C. Trautwine, Jr., spoke on the same subject.

A paper entitled, " Reasonable Requirements Imposed upon Water Works Systems by the Fire Protection Problem," by Mr. Clarence Goldsmith, C.E., superintendent of high pressure system, Boston, Mass., was read by Mr. McSweeney, and was briefly discussed by Mr. Frank L. Fuller and Mr. W. C. Hawley.

Mr. George A. Stacy.[*] *Mr. President,* I would like at this time to ask the convention to digress from the regular order of business, for I believe that what I have to say will be of interest to all of you.

As we look around upon the faces of the gentlemen present at this convention, we miss one face that has been familiar for many years to the older members of the Association at our meetings. There passed on, a week ago last Monday, a past President of this Association, who has been closely identified with its progress and prosperity. I believe that we owe it as a duty to the memory of this man at this time to recognize his many qualities that stood for good, and the interest that he always manifested not only in the Association but in its individual members.

Who is there of us who does not remember with pleasure the greeting that always came to us from Past-President Charles K.

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[*] Superintendent Water Works, Marlboro, Mass.

Walker. It was genuine. We knew that it came from the heart, and whether you met him at one of our meetings, or at his home, or on the street, or in his office, he was the same thoroughly honest man, whose integrity was as unquestioned as the stability of the hills of his own state. He was a man of sterling character, modest and unassuming in his demeanor, but firm as a rock in maintaining what he considered the right position. In discussion, Walker was fearless and struck straight from the shoulder. This was due to the rugged honesty of his character and to no malice in his heart, because no man ever had a kinder heart than our past President.

Now, gentlemen, I would suggest that you all rise and join with me in this sentiment: May our memory of him be always fresh and green. May his few faults be forgotten and his many virtues blest. Amen.

Mr. Robert S. Weston, in behalf of the officers of the Sanitary Engineers Section of the American Public Health Association, extended an invitation to the members of the Water Works Association to attend a meeting of the Health Association, to be held for the consideration of the general subject of the pollution of rivers and other streams. He also called attention to the exhibition of models of water purification plants, etc., in connection with the Fifteenth International Congress on Hygiene and Demography. In behalf of the Association the President thanked Mr. Weston for the invitations.

Mr. M. N. Baker announced that as chairman of the Conservation Committee of the Association he had received a letter from the president of the Fourth National Conservation Congress requesting the Association to appoint a delegation to attend the Congress to be held at Indianapolis in October, and that the name of Mr. F. S. Hollis, of Indianapolis, had been suggested by the Secretary as a delegate. Mr. Baker therefore moved that Mr. Hollis be accredited by the Association to attend the Congress, and the motion was adopted.

EVENING SESSION.

At the evening session Mr. Morris Knowles, director Department of Sanitary Engineering, University of Pittsburgh, Pa., read a paper entitled "State Regulation of Public Utilities."

Mr. E. C. Church, C.E., secretary Department of Water Supply, Gas, and Electricity, New York, N. Y., gave an outline of "The Organization and Administration of a Supply Bureau."

Mr. M. O. Leighton, chief hydrographer United States Geological Survey, and Mr. F. Herbert Snow, chief engineer of the Pennsylvania Department of Health, discussed the general subject of governmental control of dams and public utilities; and Mr. Babb replied to the discussions of the paper presented by him at the Wednesday morning session.

The following-named gentlemen were elected members of the Association, on motion of Mr. Morris Knowles, the Secretary having been directed to cast the ballot of the Association in their favor:

Active: F. Herbert Snow, Pittsburgh, Pa., chief engineer State Department of Health; Fred J. Wise, Pittsfield, Mass., superintendent of water works.

Associate: Carroll Beale, Washington, D. C., manufacturer of self-operating valves and designer of water works; A. R. Murphy, assistant engineer with John A. & Edward S. Cole.

The Secretary announced that the committee had made no special arrangements for the morrow, but that Mr. W. A. McFarland, of the Washington Water Department, invited the members to inspect his plant and would have his organization ready to show any part of the water system they desired to see.

The Secretary read the following report of the Committee on Exhibits, which was accepted:

WASHINGTON, D. C., September 19, 1912.

Mr. President and Members of New England Water Works Association, — I take pleasure in submitting my report as to the exhibits displayed here for the inspection of our members.

The representatives of the various manufacturers wish to express their pleasure at the interest shown by those inspecting their goods.

The following are represented:

The Pitometer Company, of New York, water measuring device.

Coffin Valve Company, of Boston, Mass., valves and sluice gates.

Ross Valve Manufacturing Company, of Troy, N. Y., high pressure fire hydrants, water regulating devices.

Pittsburg Meter Company, of East Pittsburg, Keystone and Eureka meters.

T. D. Bausher, of Reading, Pa., lead furnaces and fuel.

Union Meter Company, of Worcester, Mass., water meters and brass goods.

Geo. H. Snell, of Attleboro, Mass., pipe couplings.

Geo. H. Staples, of Dedham, Mass., service pipe cleaner.

Self-Operating Valve Company, of Washington, D. C., hydraulic valve operator.

Gamon Meter Company, of Newark, N. J., Watch Dog meters.

Lead Lined Iron Pipe Company, of Wakefield, Mass., lead and tin lined iron pipe and fittings.

Water Works Equipment Company, of New York, water works appliances.

R. D. Wood & Co., of Philadelphia, fire hydrants and " Reduced Specials."

Henry R. Worthington, of New York, water meters.

Hays Manufacturing Company, of Erie, Pa., tapping machines, service boxes, brass goods, and water works appliances.

Thomson Meter Company, of Brooklyn, N. Y., Lambert meters.

Francis H. Coffin, of Scranton, Pa., wooden pipe.

H. Mueller Manufacturing Company, of Decatur, Ill., meter testing machine, tapping machines, flushing hydrant, brass goods, and water works appliances.

National Water Main Cleaning Company, of New York, turbine water main cleaner.

Builders Iron Foundry, of Providence, R. I., Venturi meters, gages and meter boxes.

Hersey Manufacturing Company, of South Boston, Mass., water meters, detector meters.

Glauber Brass Manufacturing Company, of Cleveland, Ohio, water works brass goods.

National Tube Company, of Pittsburg, Pa., " Kewanee " unions, valves, and fittings.

National Meter Company, of New York, Empire, Crown, Nash, and Ajax meters.

A. P. Smith Manufacturing Company, of East Orange, N. J., tapping machines, brass goods, sleeves, fire hydrants, gate valves, and water works appliances.

Norwood Engineering Company, of Florence, Mass., mechanical filters.

Standard Cast-Iron Pipe and Foundry Company, of Bristol, Pa., and Malden, Mass., cast-iron bell and spigot pipe, cast-iron flange pipe, bell and spigot and flanged fittings.

Central Foundry Company, of New York, universal joints.
Engineering Record.
Fire and Water Engineering.
Engineering News.
The American City.

Respectfully submitted,

WM. F. WOODBURN,
Chairman Committee on Exhibits.

THE PRESIDENT. Is there any other business?

MR. SAMUEL A. AGNEW. I think we ought at this time to express our appreciation to the gentlemen who have contributed so largely to the success of our convention. I therefore move that a vote of thanks be extended to the several gentlemen who have presented papers here and to those gentlemen who have entered into the discussion of them; also to the Committee on Entertainment, Mr. McFarland and Mr. Stokes, and to Mr. Woodburn, who has had charge of the exhibits. Adopted.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at Buzzards Bay, Wednesday, June 26, 1912.

Present: President George W. Batchelder, and members Frank A. McInnes, George A. King, Lewis M. Bancroft, and Willard Kent.

Twelve applications were received and recommended for membership, namely:

For members: F. C. Beck, treasurer St. Johnsbury Aqueduct Company, St. Johnsbury, Vt.; G. A. Benjamin, manager Castine Water Company, Castine, Me.; J. T. B. Bowles, physiologist, Canal Zone, Cristobal, C. Z.; J. W. M. Bunker, instructor in sanitary analysis, Harvard University, Cambridge, Mass.; W. M. Davis, city engineer, Prince Rupert, B. C.; E. J. Fossas, student, 524 West 124th Street, New York, N. Y.; G. W. Hubbard, superintendent water works and light plant, Elberton, Ga.; J. J. Mack, 14 Barr Street, Salem, Mass.; J. H. Mendell, superintendent water works, Manchester, N. H.; R. H. Stearns, designing engineer, Board of Water Commissioners, Hartford, Conn.; F. P. Washburn, member New Bedford Water Board, New Bedford, Mass.; M. C. Whipple instructor in sanitary chemistry, Harvard University, Cambridge, Mass.

Voted, that the headquarters of the Association for the annual convention of the present year, in Washington, D. C., be established at the Congress Hall Hotel.

Voted, that William F. Woodburn, of Malden, Mass., be the Committee on Exhibits for the September Convention.

Voted, that President Batchelder, W. A. McFarland, and D. B. Stokes be the Committee of Arrangements for the Annual Convention.

Voted, that but three sessions be held during the Convention, namely, from 10.30 A.M. to 1 o'clock P.M. on Wednesday and

Thursday and one on Thursday evening, and that Friday be devoted to an excursion to Mount Vernon and Arlington.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at Congress Hall Hotel, Washington, D. C., Wednesday, September 18, 1912, at 10 o'clock A.M.

Present, President George W. Batchelder, John H. Cook, George A. Stacy, Lewis M. Bancroft, George A. King, and Willard Kent.

Seven applications were received and recommended for membership, namely:

For membership: Daniel F. McCarthy, chief engineer, Lawrence Park Realty Company, Bronxville, N. Y.; Charles R. Harris, Portland, Me.; Langdon Pearse, division engineer, Sewage Disposal Investigations, Sanitary District of Chicago, Chicago, Ill.; A. S. Malcomson, general manager of Hempstead and Oyster Bay Water Company, of Merrick (Long Island), Freeport, L. I., N. Y., George Neut, chief engineer, Empress de Aqua Potable, Santiago, Chili.

For associate membership: Thomas D. Bausher, water works and plumbers' furnaces, Reading, Pa.; National Tube Company, manufacturers pipe fittings, valves, etc., Pittsburgh, Pa.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at Congress Hall Hotel, Washington, D. C., September 19, 1912, at 7.30 o'clock P.M.

Present, President George W. Batchelder, John H. Cook, George A. Stacy, Lewis M. Bancroft, George A. King, and Willard Kent.

Applications of the following named persons were approved and recommended to the Association for election to membership:

For membership: F. Herbert Snow, chief engineer, State Department of Health of Pennsylvania, Harrisburg, Pa.; Fred J. Wise, superintendent water works, Pittsfield, Mass.

For associate membership: Carroll Beale, manufacturer of self-operating valves and designer of water works, Washington, D. C.

Adjourned.

WILLARD KENT, *Secretary.*

OBITUARY.*

Charles Kimball Walker was a native of Manchester, N. H. He was born on June 18, 1830. His home at 68 South Main Street, West Manchester, had been his residence throughout his entire life of more than eighty-two years.

After receiving the instruction offered by the district schools of those days, and when still a boy, he took up studies in the direction of civil engineering. At the age of twenty, he was employed in the survey for the Concord & Montreal Railroad. After three years' service, he assisted in the survey of the Wilton Railroad.

In 1852 he married Miss Ann Maria Stevens, of Wentworth, and immediately thereafter removed to New York, where he followed his profession on the New York & Erie Railroad. Later he was engaged on the Marietta & Cincinnati Railroad. Upon the completion of these enterprises, Mr. Walker returned to his Manchester home and very soon we find him employed on the Suncook Valley Railroad under the late Ex-Governor James A. Weston, who was his lifelong personal friend. He was also of the engineering corps of the East Jaffrey Railroad, the Lowell and Farmington, Hopkinton, and Montpelier and Wells River.

A little later he was employed in the surveys for the Manchester Water Works, and after its completion was in 1875 elected superintendent, and he continued to fill this position without a break until the first day of April of the present year, when he tendered his resignation. He had been in failing health for some time, his decline being gradual, and after he relinquished his activities, he gradually became more inactive, until at last he was prostrated by a shock and the end came on September 9. Mr. Walker is survived by his wife and two daughters.

Charles K. Walker was a true son of New Hampshire. He loved her rugged and picturesque hills and he seemed to imbibe something of their rough beauty in his nature. His principles of right and wrong were based upon as solid a foundation as those of the everlasting hills amid which he loved to roam. He stood squarely for those things which were honest, just, and of good report. While brusque and quaint of speech, and exceedingly frank in expressing his opinions, yet he never left a sting in the minds of those whom he addressed. On the contrary, the impression was generally whimsical, bright, and witty. Many pages could be written of the quaint sayings of our friend which under the guise of wit contain a lot of "horse sense." He greatly disliked the jarring notes of life and did everything he could to prevent their appearance.

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* Memoir prepared by R. C. P. Coggeshall.

I think that perhaps his best work in this Association was in the direction of smoothing out the angles of strife whenever they appeared. He was a master in doing that. He dearly loved this Association and he was active in its affairs from its very beginnings. When about twenty men, all strangers to each other, gathered at Young's Hotel, Boston, April 19, 1882, to consider the formation of this society, Mr. Walker was there and did much to relax the strain incidental to the meeting of a body of strangers. We all left that meeting feeling that we had found a new friend in him. He was a constant attendant of the meetings through all the long term of years and frequently took part in the discussions and debates, and his message was always acceptable. He served the Association fifteen terms as one of its vice-presidents and in 1903 he was its president.

His memory remains with those who knew him best as that of a beautiful yesterday which has passed by.

MEMBERSHIP.

ADDITIONS.

(July 1 to November 15, 1912.)

MEMBERS.

Burt, Luther W.
Civil Engineer, 39 Pearl Street, Hartford, Conn.

Carter, Frank H.
Designing and Supervising Engineer, 147 Magazine Street, Cambridge, Mass.

Harris, Charles R.
With Portland Water District, Portland, Me.

Malcomson, A. S.
General Manager Hempstead and Oyster Bay Water Company, of Merrick, L. I. Address: Freeport, L. I., N. Y.

McCarthy, Daniel F.
Chief Engineer Lawrence Park Realty Company, Bronxville, N. Y.

Manley, Henry, Jr.
11 Mt. Vernon Street, West Roxbury, Mass.

Neut, George
Chief Engineer Empress de Aqua Potable, Santiago, Chili.

Pearse, Langdon
Division Engineer, Sewage Disposal Investigations, Sanitary District of Chicago, 1500 American Trust Building, Chicago, Ill.

Smith, Sidney
76 White Street, East Boston, Mass.

Snow, F. Herbert
Chief Engineer, State Department of Health, Harrisburg, Pa.

Wilcox, W. F.
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REASONABLE REQUIREMENTS IMPOSED UPON WATER WORKS SYSTEMS BY THE FIRE PROTECTION PROBLEM.

BY CLARENCE GOLDSMITH, ASSISTANT ENGINEER, PUBLIC WORKS DEPARTMENT, BOSTON, MASS.

[*Read September 19, 1912.*]

In any water-works system the requirements imposed by the fire protection problem have very much in common with those involved in furnishing an adequate and reliable domestic supply.

The success of any enterprise is dependent upon its financial resources and the organization of its working force. Under ordinary conditions a per capita expense of from thirty dollars to forty dollars is necessary to develop an adequate water-works system. Climatic and topographic conditions, however, are the controlling factors, and in localities where expensive water rights have to be acquired, or where a wide range in elevation exists, the expense may increase to about double the above-named figures.

One of the fundamental difficulties encountered in properly developing a water-works system is the securing of necessary funds to develop the works in advance of the increase in consumption. In some cases this difficulty is due to lack of confidence in the engineering ability of the department, and in others to political reasons. No money is ever saved by postponing a proper development, for in nearly every case the delay causes a large loss by necessitating a temporary construction which is comparatively useless in the regular development of the works, besides subjecting the inhabitants to extreme inconvenience, and perhaps exposing the city to epidemic and conflagration.

Instances of dilatory tactics in financing necessary developments are, unfortunately, too numerous; in fact, a large proportion of our cities outgrow their supplies or equipment before the necessary additions are made. For example, the city of Lawrence, Mass., was warned early in 1900 that the consumption had reached the winter capacity of the filter beds, which at that time were not covered. Yet no money was placed at the disposal of the water board until 1906, when a new covered filter was contracted for, but not in time for construction work to be completed before the cold weather set in. The supply available from the old filter was so seriously depleted during the exceptionally cold weather of December of that year and the following month that early in February not more than one million gallons of water was available in the reservoir. At this time relief was afforded by water supplied from the mains of adjoining towns. If a large fire had occurred during the period of low water in the reservoir, it would have been necessary to take suction from the river, which is highly polluted with sewage, in which case an epidemic of typhoid fever would have been inevitable.

As a second example, the city of Worcester, Mass., may be cited, for we are all familiar with the conditions existing in that city during the summer of 1911, as described in the paper read before this Association by Mr. Frank C. Kimball.*

In 1902, the necessity of starting the development of the Asnebumskit supply was apparent to those who were acquainted with the needs of the city, and though Mr. Batchelder, our President, worked very strenuously each year during the intervening period to secure the necessary funds to prosecute this work, no considerable money was provided until 1911, and the result is well known.

The city of Detroit is to-day confronted by a lack of capacity in its pumping station and distributing mains.

I want to call your attention to a fact interesting to you all, which, without doubt, has a deeper influence on the results obtained by our municipal works than one would at first suppose, and that is the small salaries paid to water-works superintendents and engineers. What private corporation capitalized at from two to five million dollars would for an instant try to secure a man to direct every detail of the business for the paltry salary of from $1 800 to $3 000 a year? Yet this is what a superintendent is expected to do in a water-works system of the class above mentioned, for a wise board of commissioners will always be guided by the opinion of its superintendent in all matters pertaining to the operation and development of the works. It is to be hoped that in these days, when efficiency is the watchword, and the operation of all city departments is more carefully scrutinized than formerly by the citizens, the advisability of securing and keeping in office capable men, and adequately recompensing them, will be recognized.

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* JOURNAL N. E. W. W. A., Vol. XXVI, p. 113.

Of all the various methods of organization in vogue in the different municipalities throughout the country, no single one can be selected as a panacea. The trend of the times is to centralize authority, which is accomplished by the commission form of government and modifications of it. This method, unfortunately, does not assure the securing of properly trained men for the positions, and although the recall may be applied, it is doubtful if a second selection would be an improvement on the first. The great trouble is that so many water-works positions have been and are now being filled by men with no previous experience or training along such lines, and who attain and retain their positions through political influence, that the public is apt to be misled into the belief that any one can run a water-works system. Such an assumption is untenable, and appears absurd upon even a casual study of the question.

This undesirable state of affairs is being met by the adoption of civil service rules in many cities, and if the examinations are properly and impartially conducted, good results are bound to be obtained. Many works are operated satisfactorily under the direction of a board of water commissioners, and this method has much to recommend it. When composed of three or more members, the term of one expiring each year, such a board assures a continuity of purpose, and a new member who has been most antagonistic toward certain policies of the board may become an ardent supporter of these policies after he has had an opportunity to study the situation at short range. Nevertheless, the ever-present danger of incompetence confronts us in this case as well as in the former, and works which have flourished long under boards of water commissioners may become suddenly disorganized through the election or appointment of men subservient to political influences and more concerned about private well-being than public welfare. One must conclude from the various examples that constantly come to our attention that the responsibility reverts to the mass of citizens who control the situation by their votes, and that progress toward a more businesslike control of water-works plants must be brought about by a campaign of education. Civil service as applied to employees has many good points in its favor. It secures long terms of service for employees and relieves in a great measure those in authority from the importunities of those seeking positions for themselves or for others. The desirability of not changing employees is equally important from the standpoint of domestic supply and fire protection. Much of the work of operation is accomplished by laborers who through years of experience have acquired skill and knowledge in their work, which is almost indispensable in cases of emergency. Yet there are some cities in which the department undergoes a complete change of personnel at intervals of two years.

In order to enable the employees, when well organized, to render prompt and adequate service, complete records, properly filed, and suitable quarters are necessary. A detailed discussion of the subject of records is impossible in a paper of this character, but because of its great importance, those most essential are here briefly referred to:

A skeleton map of the distribution system on a scale of about 1 in. to 500 ft., showing mains, gates, and hydrants, is of great use for reference purposes, and of particular value in making studies for the extension or reinforcement of the distribution system.

Detailed locations in plat form on a scale of about 1 in. to 40 ft., showing mains, gates, and hydrants, are indispensable, and it is convenient in many cases to show service connections on these sheets as well.

Records of service connections, gates, hydrants, and meter locations should be arranged in card index form.

The location of gates on the distribution system and those on services larger than two inches in diameter should be arranged in convenient form for ready reference, and copies of these records should be supplied to all employees authorized to operate gates.

Records of pumpage or delivery of flow lines, as made by one of the several accurate continuous-recording devices now on the market, should be kept, and the pumping station records should show the complete performance of the equipment.

Records of pressure maintained at several points of the system should be secured by the installation of recording pressure gages.

The above-mentioned records, together with such necessary and desirable amplifications as may be called for, should be kept up to date. The more important plans and records should be in duplicate, and one set should be stored in a substantial fireproof vault. The question of guarding records against destruction by fire cannot be too strongly emphasized, and it is to be regretted that it is a subject which is often completely or partially neglected. The ordinary fireproof vault is of questionable efficiency in a conflagration, and in many cities it is the custom to provide safe storage at the supply works, but removed from the danger of sweeping fires.

The engineering office, which generally occupies a building in common with the executive and clerical forces, should have ample area for carrying on the maximum amount of work which is liable to devolve upon this branch of the service during periods of active construction. The room or rooms should be properly ventilated and supplied with both natural and artificial light. Partitions should be so constructed that the occupants shall not be subject to the intrusion of the public, or other distraction. Well-arranged filing cases and vaults should be readily available for the storing of all plans and records. A library should be provided which should contain the latest editions of the most desirable handbooks and scientific works bearing on the various subjects which have to be dealt with in the design, construction, and operation of a water-works system, and in addition a file of the best engineering magazines should be available, so that the working force may keep in touch with work of a nature similar to their own carried on in other cities.

The storage yard, usually containing a repair shop and stable, should be of ample area, and so located that shipments of material may be conveniently and economically handled both from the cars and in the area covered by the distribution system. The yard should be so laid out with paved drives that all the stock shall be readily accessible, and chain falls, with either derricks or cranes, should be provided for handling the heavier pieces. Fittings, valves, and hydrants may well be kept in covered sheds. If the yard is located in a closely built-up district, it is particularly desirable that the buildings be of fireproof construction; otherwise, they should be equipped with sprinklers, standpipes, and hose. The shop should contain tools of the kinds and sizes required to do all but the heavier repair work, and particular attention should be paid to the lay-out of the meter repairing and testing rooms. The offices of the several branches of the work should be connected by telephone, and constant watch should be maintained at the repair shop in all cities having a population of over fifty thousand. The requirements mentioned thus far are necessary for the construction and maintenance of a water-works plant furnishing a reliable domestic supply.

Fire alarms should be received over the gong or tapper circuit of the fire-alarm system in one or more offices of the department, and at least one employee familiar with the distribution system and prepared to operate gates should respond to all first alarms in mercantile and manufacturing districts, and second alarms elsewhere. Provision in duplicate should be made for notifying the pumping station of alarms.

The experience of many departments, as well as of public service corporations engaged in similar work, is that the motor-driven vehicle has become a necessary adjunct to the equipment of every water-works system. It enables a prompt response in case of accident, and increases the efficiency not only of the executive force, but also of the laborers in many branches of the work.

There is hardly a plant of any magnitude on which one or more automobiles cannot be profitably operated.

The source of supply must be carefully studied before its adequacy from the fire protection standpoint can be determined with certainty. The total quantity of water used for the extinguishment of fires is proportionately very small, being approximately one tenth of a gallon per capita per day, or in round numbers about one thousandth of the total consumption, but for short periods of time the rate is very high. From a perusal of the consumption records of any well-operated works, the maximum hourly, daily, and monthly rates can be readily determined, and from a study of the structural conditions in the city — areas, heights, protected openings, exposures, occupancies, construction of buildings, etc. — the probable maximum quantity which would be required to combat a fire of large proportions can be estimated within reasonable limits. The number of fire streams required simultaneously in cities of average character has been discussed by our leading hydraulic engineers, with practical unanimity of opinion. Their estimates are based on actual practice, and the values given by Mr. Kuichling are expressed by the formula $Y = 2.8\sqrt{x}$, where Y equals the number of 250 gal. streams and x equals the population in thousands. This formula does not make any allowance for broken services, and should be applied only after a study of the local conditions has been made, for in many cities the size of the mercantile or manufacturing districts is not in proportion to the population. A very full discussion of this subject was presented to the American Water-Works Association last year by Messrs. Metcalf, Kuichling, and Hawley.* Although the chance of a large fire occurring during the hours of maximum consumption is somewhat improbable, nevertheless it is wise to err on the side, and to use the maximum hourly consumption figure in the calculations, although in most cases the maximum daily rate may be used with comparative safety. This step is not so unreasonable as at first appears, for any city should have its supply developed somewhat in advance of present requirements, in order to care for future growth. In cities not exceeding one hundred thousand in population, where the lawn-sprinkling is restricted to certain periods of the day, it is feasible to enforce an ordinance prohibiting irrigation during the progress of a fire, thus materially reducing the maximum rate for which the city would otherwise have to provide. In some cities, dependent upon fire engines, the pressure is so reduced by large fire drafts that the domestic consumption rate will drop appreciably. Such distribution systems cannot, however, be considered adequate for the service required of them.

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* Proc. Am. W. W. Assoc., 1911, p. 55.

There are many cities located on large lakes and rivers where a practically unlimited supply is available, and one does not have to give the question a thought, but in others it is a most important question with the engineer. In these latter the problem is varied, but resolves itself into some method of storage so that the maximum rates can be delivered to the distribution system. If the supply is derived from driven wells, they should be so developed as to furnish the maximum daily rate, and the maximum hourly and fire-flow rates may economically be cared for by storage in a covered reservoir available for delivering into the distribution system. If the supply is derived from storage from a large catchment area, the capacity of this storage should be ample to meet the demands made upon it through a series of dry years. In dealing with such a supply, the average daily consumption, and not the varying hourly rates, must be considered in determining the minimum capacity of the storage reservoirs.

The source of supply having been determined, the method of delivery to the distribution system confronts us. In many cases where the supply is derived from rivers and lakes, and generally when delivered from storage reservoirs, these sources are at an elevation sufficient to deliver the supply by gravity. In a few cases the topography of the country is such that the sources of supply are in close proximity to the distribution system, but in by far the greater number they are at some distance. In the latter cases, distributing reservoirs within or near the area served by the distribution system become an economical necessity, for their existence permits the use of much smaller conduit lines. These lines should have a capacity at least equal to the maximum daily consumption, and one such line cannot be depended upon unless the storage in the distributing reservoir is ample to furnish the supply during the longest period that will be required to make repairs. The conduits delivering the Catskill supply to the city of New York, the Owens River supply to Los Angeles, and the Wachusett supply to the Metropolitan District of Boston, are not in duplicate, but the permanency of their construction and the storage provided along their routes and at their termini assures the continuity of the supply. On systems where there is more than one supply line, these lines should not follow the same route, as the failure of one may cause the failure of another, or both may be put out of service at the same time from the same cause, as was recently the case in Seattle, Wash. Where pumps are required to deliver the supply to the distribution system, the pumping station should be of fireproof construction. No valid excuse can be offered for not constructing stations absolutely fireproof. The installation of sprinkler equipment, standpipes equipped with hose, and chemical extinguishers, in the many existing stations which are not fireproof, should be strongly advocated. In all cases, oil should be stored outside the building, and all internal hazards should be reduced to a minimum. When stations are exposed to external hazards, outside sprinklers, water curtains, and wire-glass windows should be provided. On buildings having incombustible roof coverings and cornices these give reasonable protection.

The selection of the equipment of the station requires careful study in order that units of proper capacity and number to insure economic and continuous service may be provided. Plants which are supplied by pumpage may be broadly divided into three classes, namely, those which distribute from a storage reservoir, from an equalizing reservoir, and direct from a station. Under the latter class those which are supplied with an equalizing standpipe should be included, for in only small towns can a standpipe furnish any reasonable proportion of the draft, and in the larger cities it is a useless adjunct, as the pressure can be as uniformly maintained by means of pressure governors.

The stations which deliver direct to the system will first be considered. Their pumping capacity should be sufficient to deliver the maximum domestic and fire draft combined, with any two units in reserve; and the boiler capacity should be sufficient to enable the pumping of this maximum draft by the most uneconomical units in the station, with one boiler out of service for repairs or cleaning. This requirement of two reserve pumps over and above the maximum capacity has frequently been questioned, one of the foremost objections offered being the large amount invested for machinery which may never be called into use. The answer to this objection will be given along the line of cost. If the city were located in close proximity to a hill of sufficient elevation to furnish the desired pressure, the advisability of building a reservoir of sufficient capacity to assure the supply would not be questioned. Such a reservoir would cost, in round numbers, about $5 000 per million gallons, which corresponds closely with the cost of high-duty pumping machinery of equal capacity; and low-duty or centrifugal pumps can be purchased at a much lower figure. Viewed from the cost standpoint, therefore, no argument can be adduced against installing pumps to perform the same function as the reservoir.

Where an equalizing reservoir is in service, the pumping capacity need not be as great as in the preceding case, but there should be one unit in reserve over and above the maximum possible draft for ten hours, minus the reservoir capacity. When a station delivers to a storage reservoir, the pumping capacity should be equal to the average daily draft during the maximum month. Such capacities may perhaps appear high to many who have successfully maintained an ample supply from stations which are not equipped with the above-mentioned reserve units, but no station can be considered reliable unless it can maintain the supply at all times, and it is not infrequent in a station containing four or five units for two to be out of service at the same time, and, although one of the units may be undergoing only trivial repairs, such as replacing valves or packing glands, it would nevertheless be impossible to get it back in service on short notice.

The capacity for coal storage should be sufficient to hold fuel enough to run the plant through any period in which the delivery may be interrupted by strikes or unfavorable weather conditions, and coal to meet such emergencies should, of course, be kept always on hand.

If the water is delivered direct from the pumping station to the distribution system or to an equalizing reservoir, there should be two or more discharge mains, and their capacity should be such that with any one main out of service, the other or others could deliver somewhat in excess of the maximum domestic consumption; and, of course, it would be much more desirable if, under such circumstances, the maximum domestic and fire draft combined could be provided for. When delivering into a storage reservoir, one main having a capacity equal to the maximum daily rate is ample, for repairs can be made before the water in the storage reservoir will be exhausted.

To-day filtration plants are in operation in many cities, and the capacity of these plants need not be as great as the maximum hourly rate of consumption if enough filtered water is held in storage at some point on the works to provide for the drafts. On many plants this supply is provided by large covered clear-water basins which supply the high-lift pumps. In some plants a bypass is installed so that unfiltered water can be delivered direct into the distribution system in case the fire draft exceeds the capacity of the filters and exhausts the supply in the clear-water basins. Where the original source is contaminated, however, this expedient should not be resorted to, but provision should rather be made for additional clear-water storage, as an epidemic is even more undesirable than a conflagration.

The supply mains connecting the storage or equalizing reservoir with the distribution system should be bypassed around the reservoir, and of such capacity that the maximum rate can be delivered with any one main out of service. In some cases, the installation of cross-connections and suitably located gates in the supply mains enables their size to be somewhat reduced. Blow-offs should be established at all low points, for it often requires more time to empty a main and dispose of the water than it does to accomplish the actual repair work.

In the construction of force and supply mains, the question of material is often difficult to settle. Cast iron, wrought iron, steel and wood are each used with good results. Up to thirty inches in diameter, cast iron generally proves the more economical, but in larger sizes steel lines prove cheaper even if they have to be replaced within twenty-five or thirty years. Besides, it is impracticable to use cast iron in mains of more than sixty inches in diameter. The carrying capacity of lines constructed of either material gradually decreases, but the cast-iron lines can be cleaned and their capacity restored at a nominal cost. On the other hand, cast iron is subject to rupture, which will put the line completely out of service, while in the case of steel any general weakening of the structure is portended by small leaks. Continuous wood stave pipe has proved very reliable; it is almost always cheaper, can be readily repaired, and maintains its carrying capacity throughout its life.

All force and supply mains should be equipped with air valves at their high points, and they should be frequently inspected, for a defective air valve will cause a steel or wood line to collapse in case of a break at one of the low points.

There is no better item to observe than the per capita consumption records if one cares to make a snap judgment in regard to the efficiency of the operation of a water-works system, for almost invariably the high consumption rate is a sign of inefficiency, and, conversely, the low consumption rate is indicative of efficiency. The per capita rate which is necessary to meet modern conditions in our cities ranges from about 50 to 150 gallons per day, but these rates are exceeded in most of them. This unnecessary consumption has a very important bearing upon the question of cost, for it has to be met by the development of larger supplies, the construction of additional filtration works (if there are any), and the installation of additional pumping equipment and of force, supply, and distributing mains of increased carrying capacity, if the domestic and fire-flow requirements are to be fully met. Unfortunately, in such instances the fire-flow is generally only partially provided for during periods of maximum domestic consumption.

The installation of meters is the surest and practically the only way to effect a permanent reduction of the per capita rate. Many and fallacious as are the arguments advanced by the opponents of the general installation of meters, the results where they have been installed are incontrovertible. Water-works engineers are not as yet agreed that the metering of all services is an economic necessity, but the results attained in cities that have metered practically every service show that as much benefit may be derived from metering the last ten per cent. of services as was obtained from any prior installation of an equal number of the same size. The water used in public buildings and for other municipal purposes is generally far in excess of that actually needed. In cities which have paid particular attention to this class of consumption, the conclusion reached is that all water used by the several city departments, except for the extinguishment of fires, should be metered and paid for by the users. Such a course not only effects an important reduction in consumption, but gives the water department credit for the service rendered.

One of the points upon which insurance and water engineers differ is in regard to the metering of fire services. The water-works engineer, who generally takes the affirmative side of the question, is in much closer touch with the situation, and when such results as the following are obtained, there seems to be no doubt in regard to the justification of his stand.

Worcester, Mass., metered all fire services in 1905, and the following year the revenue increased $15 000, and the consumption decreased over 300 000 000 gal.

Lockwood, N. Y., metered all fire services, and the following year the revenue increased 25 per cent. and the pumpage decreased 20 per cent.

The pressures which are maintained on works which are supplied by gravity from distributing or equalizing reservoirs are governed by the elevation of the reservoirs. In many cases suitable sites are not available at desired elevations, but when they are, it is highly desirable to so locate the reservoir that a pressure of 100 lb. will be maintained over the greater portion of the distribution system, and particularly in the closely built-up sections. In a recent paper,* Mr. E. V. French dwelt upon the advisability of such a pressure, and showed that it was sufficient to furnish direct hydrant hose streams to all fires except those in the larger and higher buildings, for which more powerful streams would have to be furnished by fire engines. As the number of fire engines can be greatly reduced if many streams can be taken direct from the hydrants, a very considerable saving can be thus effected, for it costs between three and four thousand dollars a year more to maintain an engine company (horse-drawn) than to maintain a hose company. In planning for extensive improvements in any city, therefore, it is desirable to provide, if possible, for the raising of the pressure to about 100 lb., for in addition to cutting down the expense of the fire department, other economies can in this way be also effected. Take, for example, the large cities of New York, Chicago, Philadelphia, and Buffalo: in these it is necessary to pump all the water used in buildings of moderate height and in small plants, and this could be done more economically in one central station. Of course it would still be necessary to pump the supply to buildings over 200 ft. in height, but these are comparatively few.

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* JOURNAL N. E. W. W. A., Vol. XXV, p. 247.

Next in importance to the saving which could be accomplished is the increased reliability of sprinkler equipments when supplied from a central station. The number of such equipments in service is increasing rapidly, and they constitute practically the only safeguard to buildings of non-fireproof construction and fireproof buildings containing combustible material. In many systems supplied by direct pumpage provision is made to raise the pressure upon receipt of fire alarms and maintain this pressure until the "all-out" is sounded. This practice is good, and may well be adopted in all such systems. The permanent raising of pressure on a system does not necessarily increase the consumption, for thorough inspection and the prompt following up of defects will enable an unincreased consumption rate to be maintained. This has been proven in several cities during the past few years, and though heavier materials, requiring more careful workmanship, are used in the original installation, the subsequent cost of maintenence of a distribution system under 100 lb. pressure is no greater than under 50 lb. pressure.

Few engineers have the opportunity to design a new distribution system for a city of any considerable size. New Orleans is the only large city which has installed a new piping system in the last score of years. The problem of to-day is the reinforcement and rehabilitation of outgrown distribution systems, or of systems which have deteriorated in carrying capacity or were faulty in their original design. To accomplish this task, a careful study of the existing system should be made, present requirements determined, and proper allowance made for future growth. This done, a plan for all future work should be adopted and followed. This plan should include main arteries of ample carrying capacity girdling the city as its growth demands, secondary feeders of suitable size about 3 000 ft. apart in either direction, and dead-end lines extended to outlying sections without reduction in size, — the system to be so designed as to furnish fire protection as follows:

(*a*) In outlying residential districts not likely to become closely built up, a minimum of 1 500 gal. per minute.

(*b*) In closely built-up residential and minor mercantile sections, 2 000 to 5 000 gal. per minute.

(*c*) In manufacturing, warehouse, and congested value districts, from 5 000 to 20 000 gal. per minute, depending on the structural conditions.

The above supply should be in excess of the maximum daily domestic consumption, and should be available in manufacturing districts to any large group of buildings of special hazard, and in mercantile and residential districts about any block. In order that these quantities shall be available, the following minimum sizes of mains should be used for hydrant supply:

For residential districts, 6-in. and 8-in. mains, the former to be used only where they complete a good gridiron, and the latter in locations where dead-ends and a poor gridiron are likely to exist for some time, and in all blocks 600 ft. or more in length.

For mercantile and manufacturing districts, 8-in. and 12-in. mains, the former to be used only in sections where they complete a good gridiron, and the latter for long lines not cross-connected.

Four-inch mains cannot furnish sufficient hydrant supply, and should be replaced as fast as circumstances will permit, the replacement to commence in the more thickly built-up sections. In order that not more than one hydrant will be on a 6-in. nor more than two hydrants on an 8-in. main between intersecting lines, dead-ends should be eliminated wherever practicable, large mains cross-connected to distributors at all intersections, and long unsupported lines of pipe cross-connected.

The city of Reading, Pa., affords a good example of the results which may be accomplished by the adoption of a well-designed plan to be followed out in future construction. Some seventeen years ago such a plan, prepared by the superintendent, Mr. E. L. Nuebling, was approved by the city, and has been followed since that time. At present there are ample quantities of water available for both domestic and fire protection purposes throughout the entire system, and future additions to meet increased growth in population can be readily and economically made.

Unfortunately, the topography of some cities precludes the making of plans for future growth, for it is impossible to foresee in what direction that growth will extend. For a number of years the probable growth of Los Angeles appeared to be in an easterly direction, and it is only in the past two or three years that a definite trend showed it to be in a westerly and southerly direction.

Tar-coated cast-iron pipe is unquestionably the best material to install in a distribution system. In some parts of the country kalameined pipe is extensively used, because of the saving in freight rates which can be effected on account of its lighter weight, and this pipe gives very good results. Machine-banded wooden pipe does not give satisfaction in a distribution system on account of the excessive leakage which generally occurs. Cast-iron pipe should be inspected at the foundry and again before it is lowered into the ditch. Special care should be taken to prevent any foreign matter from getting into the line during laying, and the line should be thoroughly blown out before it is put into service. If practicable, a test pressure of one and a half times the working pressure should be applied to the line before backfilling.

Pipe less than 6 in. in diameter should never be installed to furnish hydrant supply. In cities where the distribution system is weak, it is desirable not to install any pipe less than 8 in. in diameter, for the new lines of these larger sizes will reinforce the old lines. The weight of pipe purchased should be sufficient to enable at least 300 ft. head to be maintained at the point of lowest elevation in the city. If the heavier classes of pipe are installed, it enables the pressure on the system to be raised to the desired point without the additional expense which would otherwise be required for relaying. The coefficient of carrying capacity of the older lines should be determined by experiment, and in many cases, where the supply is deficient, the results obtained will show that it is more desirable to clean the line than to lay a new line. Sufficient cover should be provided to insure the pipe from freezing, even in the coldest winter. Exposed pipes at bridge crossings should be well supported and protected from injury, and extreme care should be paid to the design of the line near the approaches.

Electrolysis is a subject which must not be neglected, for it is most insidious in its action. Frequent surveys should be made, and remedial measures approved by the best water-works practice, rather than those generally advocated by street railroad engineers, should be adopted. Grounds from electric circuits should be made on the street side of the meters, main cocks, etc., in accordance with the National Electrical Code, and no power circuit which depends upon a grounded return should be connected to the system in any manner.

In order to operate a distribution system with the desired facility, the mains should be equipped with gate valves so located that no single case of accident, breakage, or repairs to the pipe system in important mercantile and manufacturing districts will necessitate the shutting from service a length of main greater than the side of a single block, or a maximum of 500 ft., or in other districts a length greater than two sides of a single block, or a maximum of 800 ft. If possible, the location of gates should be uniform; that is, they should be set on the property or curb lines at street intersections, so as to be more readily located. On paved streets it is advisable to provide a box or vault of sufficient size to permit of packing the gland without excavation. When the approximate location of a box is known, and it is covered by dirt on an unpaved street, or by ice, a pocket compass will prove an invaluable aid in determining its exact location, for by passing the compass over the supposed location, about an inch above the ground, the needle will deflect toward the iron cover, and by a little careful work can be made to indicate the exact center of the cover. The compass will determine the location of a box that is covered as deep as one foot. This method is also of use in finding cast-iron service boxes which have been covered by granolithic sidewalks.

The gate valves on a system should be inspected at least once a year, at which time they should be operated, and packed if necessary. The boxes should be kept clean, and if water is liable to collect and freeze in them, they should be provided with a drain to the sewer or be pumped out. All operating nuts should be of the same size, and all gates should operate in a uniform direction. On a system of any considerable size, gates should only be operated by employees specially assigned to the work, and a record should be kept by them of each operation.. Careless inspection and operation is sure to cut down the carrying capacity of the system by allowing some gates to remain closed, and frequently causes serious delays in cases of accident. Occasionally division gates between different services are left open, and the apparent increase in consumption in the higher service is puzzling to the superintendent until the cause is discovered. In one city where a record of gate operation was not kept and inspections were infrequent, an examination of 7 000 valves showed:

49 closed and 300 partially closed valves on lines from 4 to 20 in. in diameter.
12 inoperative valves.
100 valves either not on the plans or not in the ground.
2 gate vaults completely filled with crushed stone.
1 division gate open.
1 952 boxes requiring cleaning.

In a smaller city an inspection of 40 valves showed:

1 valve closed.
1 valve with a broken spindle.
1 valve so deep that it could not be reached with the wrench.
2 valves operated in a direction opposite from the others, and no note made of the fact on the plans.
2 valves inaccurately located on the map.
3 valve boxes filled with bricks and earth.
1 operating nut too large for the wrench.

The hydrant is the last link in the chain from the source of supply to the point of delivery to the fire hose lines. Hydrants should have 6-in. barrels with 6-in. gated connections to the main and a foot valve having a free waterway of at least 20 sq. in., so that the loss when 1 000 gal. are being withdrawn shall not be excessive. In cases where provision is made for more than one engine to take suction from a single hydrant, the above dimensions should be increased, and no loss greater than 4 lb. should be permitted when hydrant hose streams are utilized. The operating nuts of all hydrants in a system should be of uniform size and turn in the same direction. Where hydrants are supplied from different services it is advisable to paint those on separate services a distinctive color. Care should be taken to have the threads on the outlet nipples of the same size as that adopted by the fire department for hose couplings, and it is especially desirable to adopt the National Standard hose thread, so that apparatus summoned from neighboring cities can make connections.

Hydrants should be frequently inspected to assure their operation. They should be packed and lubricated, and the outlet caps greased, at least once a year, and they should then also be operated and blown out. Before cold weather sets in they should be carefully inspected for drainage, and if any are set below the ground-water level the drips on such should be plugged and the water in the barrel pumped out. During periods of cold weather those in high-value districts should be inspected once a day, and those in other sections twice a week. Special connections should be provided for filling flush wagons and sprinkling carts, and the use of fire hydrants should be confined solely to the fire department.

The question of the distribution of hydrants in a city is a very important one from the fire department standpoint, on account of the great friction loss in long lines of hose. The distribution should be such that ample quantities of water can be delivered to a large fire from hydrants at an average distance therefrom of not more than 350 ft. The customary method of figuring hydrant spacing on a linear basis does not convey any definite information, for, without a knowledge of the size of the blocks, linear spacing would be apt to convey an erroneous impression. For example, the locating of hydrants at linear distances of 200 ft. in one city where the blocks are 200 ft. square would, in the matter of distribution, be equivalent to the locating of hydrants at linear distances of 100 ft. in another city where the blocks are 800 ft. square — in either case the area served by a single hydrant being 40 000 sq. ft. Under the differing block conditions referred to, Portland, Ore., illustrative of the former, would require one hydrant at each street intersection, or one hydrant to a block; while Salt Lake City, illustrative of the latter, would require 16 hydrants to each block between the center lines of the four bounding streets. It is clear, therefore, that the area in square feet served by each hydrant is the proper unit to adopt in order to be able to determine the adequacy of hydrant distribution and to make comparisons. Where it is necessary to concentrate 10 000 or more gallons of water per minute upon any building or block, there should be one hydrant for each 40 000 sq. ft. In minor mercantile and small manufacturing districts and in densely built-up frame areas, there should be one hydrant for every 60 000 sq. ft., and as the buildings become less congested the distribution may become wider, up to 120 000 sq. ft. in outlying residential sections.

From the operating standpoint the inside independently-gated hose outlet cannot be considered as giving the best results. The leverage furnished by the wrench ordinarily used by the fireman is far in excess of that required to operate a valve of equal size in any other service, and so great that the stem can be broken or other parts crushed without any undue exertion on the part of the operator. The end to be attained may best be accomplished by attaching outside hose gates before the hydrant is open, and such a procedure will not introduce an objectionable delay. Such gates carried on hose wagons are more reliable, as they can be easily inspected and kept in working order.

The matter of original expense is also a very important item. Assume a city with 2 000 hydrants and 16 hose or engine companies. To equip the 2½-in. outlets on all the hydrants would cost over $20 000, while to supply the 16 companies, each with four hose outlet valves, would cost about $650, and the cost of maintenance would be in about the same proportion. It is not so practicable to deal with the 4½-in. steamer outlets in the same way, because the portable valve is much heavier, so where it is desirable to connect a steamer to a hydrant which may already be delivering to a hose line, or where there are two steamer connections on a hydrant, it proves more convenient to equip these outlets with inside gates.

The purchaser of a hydrant should insist upon having the waterways carefully designed, the castings smooth, and the workmanship good. The neglect of these points often admits of the installation of a type of hydrant which is well-nigh valueless. There are hydrants in service in some cities to-day which show a loss of 35 lb. between the street main and the hose outlet when 600 gal. of water are being drawn, whereas there are many hydrants of reliable make and at reasonable cost which can deliver the same quantity of water with a loss of less than 4 lb.

The requirements necessitated by the fire protection problem are, of course, a large factor in the cost of a water-works system, increasing that cost from 50 to 100 per cent. over what it would be were the question one solely of furnishing water for domestic and business purposes. But these requirements have to be met, and while in no one city are they all fully provided for, a large number of our municipalities are earnestly endeavoring to attain the best possible results in this connection, and it is to be hoped that their example will be speedily followed by those that now lag behind in the matter of water-works administration.

It is evident from the foregoing that the fire protection problem is one of the first importance for the water-works engineer, for it is primarily with him and the fire department that its solution lies. It is perhaps not to be expected that any water-works system will fully meet its requirements in all their complexity of detail, but while the ideal is never attainable, it is always more and more nearly approachable. That it may be the more nearly approximated to in the design, construction, and maintenance of a water-works system, our municipalities should make it an indispensable part of their policy to secure for this work the best engineering talent available, and then leave it unhampered by political or other considerations to pursue its course toward the realization of what men are striving for and municipalities hoping for, — the watchword of the century, — a maximum of efficiency at a minimum of cost.

DISCUSSION.

Mr. Frank L. Fuller.* Mr. President, I think the author has set a high standard for water-works construction, and while there are details as to which engineers and water-works men would differ, still it seems to me that on the whole he has given us an admirable lay-out. He deals, perhaps, more particularly with systems for cities and large towns, while works that are being built at the present time are generally for smaller towns, and the requirements for them, therefore, would probably not be equal to those represented in this paper.

Mr. W. C. Hawley.† Mr. President, this excellent paper has covered the ground thoroughly, and every practical water-works man will agree to a very large extent with the opinions which have been expressed. It brings us to the question of the cost of all of these things which enter into the construction of a well-designed and well-built water-works system and *who is going to pay for them*, and that, I believe, is one of the matters that we have got to study into, and about which we must educate the public. Those of us who are connected with privately owned plants are confronted with this problem constantly. A neighboring municipal plant is selling water at a low rate per 1 000 gal. and is not charging for fire protection. Nothing is said as to how much is being raised in the municipality by direct taxation on account of the municipal water department or the quality of service or that probably no depreciation is being earned, and the result is that the comparison of rates between the municipally owned plant and the privately owned plant is most unfair, and yet a large part of the community supplied by the latter is firm in its belief that the grasping private monopoly is robbing the people because its rates are higher than those charged in the municipality.

The investment in water-works plants for furnishing fire protection may vary from 80 per cent. of the total cost of the plant in the case of a small water works down to a very small percentage of the total cost in the case of a large one. It is not fair that the expense of furnishing fire protection should be met by the domestic or the industrial rates, but it should be met in the case of the municipal plant by direct taxation, and the people should know what they are paying for and what it costs. In the case of privately owned plants a charge to the municipality must be made for fire protection, to be raised by taxation, or else the cost of furnishing fire protection must be added to domestic and industrial rates. Few, if any, water companies are charging what it is actually costing them to furnish fire protection, to say nothing of a reasonable profit upon the business. The computation of the cost of furnishing fire protection is a matter requiring skill and judgment, and cannot, of course, be made with great accuracy. In its calculation, however, so far as I know, every question involved has been solved by giving the benefit of the doubt to the fire protection; and even when a minimum cost has been computed, few, if any, water companies have named rates which would return the cost of the service. In some cases it has been customary to purposely add a part of this cost to domestic rates, and this has been justified on the ground that fire protection is received on both buildings and contents and that in many cases the contents do not belong to the owner of the building but to the occupant, who is either directly or indirectly the one who pays the domestic rates, and in this way he bears a share, at least, of the cost of furnishing fire protection.

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* Civil Engineer, Boston, Mass.

† Chief Engineer, Pennsylvania Water Co., Wilkinsburg, Pa.

Rate-making in the past has been to a large extent a matter of guesswork, but with the introduction of public utility commissions throughout the country, rate-making will be put on a more scientific basis. Sooner or later, we are all going to be confronted with this problem, and we shall have taken a long step in advance when the public comes to know something about the investment necessary to furnish fire protection and what it costs, and meets it by direct taxation instead of by some species of indirect taxation as at the present time.

SOME DIFFICULTIES ENCOUNTERED IN TUNNEL AND SUBWAY CONSTRUCTION IN BOSTON.

BY FREDERIC I. WINSLOW, ENGINEER OF EXTENSION, WATER SERVICE, PUBLIC WORKS DEPARTMENT, BOSTON, MASS.

[Read November 13, 1912.]

This paper is divided into several parts, the first relating to the pipe changes in connection with the various subways built to date in this city; the other parts describe two compressed air tunnels; the building of the Deer Island Reservoir, and some other work on which the author has been employed.

TREMONT STREET SUBWAY.

When the first subway was built in 1895 — about 1 200 ft. of Tremont Street was taken for its location. The City had had since 1847 along this line two 30-in. pipes laid about 5 ft. apart on centers, and the subway roof came either just up to or just above the level of both these pipes. It was proposed at that time to relay them entirely away from and around the subway so as to avoid all difficulty of caring for them during construction, and later events have rather proved the wisdom of such a course. It was, however, not adopted, and it therefore devolved on the water department to maintain these pipes by shifting, raising, or lowering them as was necessary for the construction of the subway, all with the coöperation and assistance of those in charge of building it.

The subway was constructed by the "cut-and-cover" system; that is, alternate sections of about 20 ft. were opened at the same time and work carried on under cover of planks at the street surface. Work was never stopped, either at night, on Sunday, or on a holiday. The city maintained but one inspector on the work all the time, with three shifts. The conditions found after several breaks had occurred demonstrate and emphasize the importance of the thorough inspection of work involving the foundations for heavy pipes.

There were at the same time perhaps twenty of these 20-ft. sections being worked on, in various stages of construction. The instruction given to every one concerned was to allow no rigid material to be set nearer to the bottom of the pipe than 4 in., that is, the pipes, as the old foundations were undermined, were set on 4 in. of blocking, and the subway roof was carved out under the bells where necessary to allow 4 in. of earth between the pipe and any rigid material underneath. These orders, if faithfully carried out, would have prevented large financial loss and annoyance from breakage, although to have carried them out would have required at least four times as many inspectors as were employed, and it was not at that time realized that such plain directions as were given would be so disregarded. There have been, so far, eight breaks of either one or the other of these pipes over the subway, costing for repairs about $9 000, and over

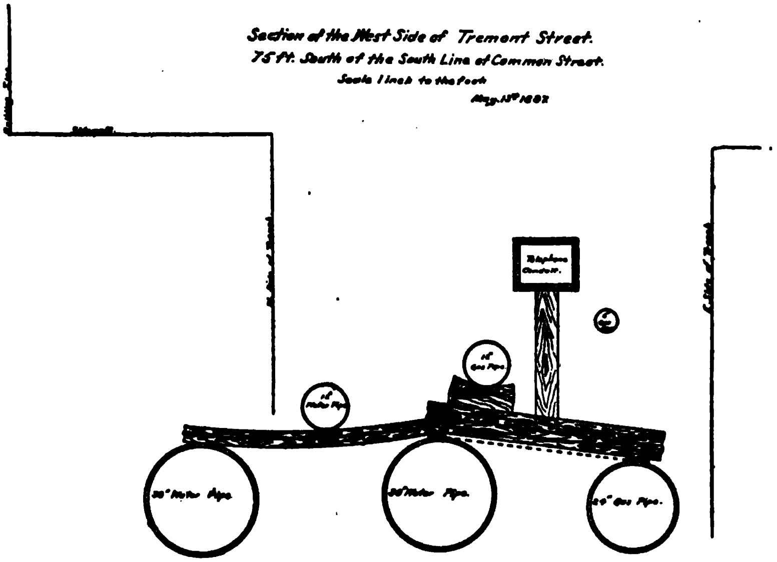

Fig. 8.

$50 000 more for damages. In every case where a pipe broke, it was at a point where it could settle, in close proximity to a rigid bearing where it was so firmly held that it could not yield, and under the enormous leverage the pipe cracked invariably along the center line of the bottom. Figs. 8 and 9 show sections of the pipes as found after the breaks.

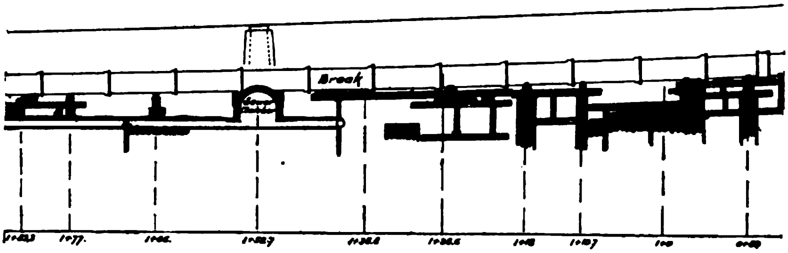

FIG. 9.
SHOWING SUPPORTS FOUND UNDER PIPES.

The two 30-in. mains before referred to had to cross the subway at a point on the Common, and, on account of the head room over the subway being so slight, these pipes had to pass under it. This was done by means of a sub-subway about 40 ft. below the surface of the Common, the pipes at this point being 30- and 40-in. respectively. The old pipes were maintained in service until the new ones were turned on, the work being done at night, on Sunday, and on a convenient holiday. The angle made by the pipes with the crossing was so acute as to make the length considerably longer than the width of the subway.

It is the policy of the water department to use as few single-casting quarter-bends as possible, especially in the larger sizes, so that two one-eighth bends had to be used wherever a 90-degree curve was necessary. As has been found many times, and probably referred to in past meetings of this Association, two eighth-bends rarely fit so as to make one quarter-bend, due probably to improper allowance made for shrinkage at the foundry. It was after considerable trouble, therefore, that these bends were finally fitted and anchored in place. The manner of anchoring is shown in Fig. 10.

Reinforcing rods were so set as to hold the masonry in place against a considerable head in case any leak should develop in the pipes, the water appearing first at a manhole on the surface of the Common. The shafts are filled around the pipes solidly with concrete, the curves in addition being anchored in place. This work was designed by the Transit Commission.

During the construction of the subway one of the 30-in. mains was moved laterally about 5 ft. and at the same time lowered 18 in.

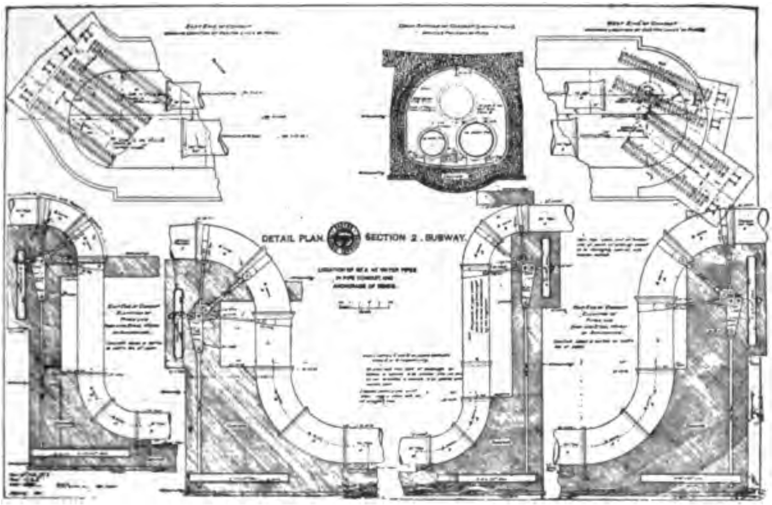

FIG. 10.
THE 30-INCH PIPE CROSSING UNDER THE SUBWAY, SHOWING THE METHOD OF ANCHORING.

This was accomplished at one operation. The pairs of timbers between which the lifting screws were operated were set on an incline on rollers, the lateral movement being made by barring, the pipe then dropping by its own weight as the screws were simultaneously loosened. Plate XII, Fig. 1, shows the method of shifting this pipe.

THIRTY-INCH STEEL PIPE.

When the second subway, or tunnel, so-called, was built under Washington Street, it was decided to avoid all possible future trouble, at least over the subway, by laying about a mile of 36- and 24-in. pipe around and well away from the site of the work. This was done by the regular force of city laborers, chiefly on account of the supposed difficulty of doing this kind of work by contract in crowded city streets. This is the first case of a pipe of this size laid through the extremely congested streets of Boston. It was slow and expensive work, and many corporations felt that their vested or acquired rights in the streets were being ignored, and although every attempt was made to avoid the disturbance of other structures wherever possible, many of them were compelled to give way as the main was laid. Where the Washington Street tunnel was crossed, two right-angle turns were made, about 25 ft. apart.

As it was an exceptionally poor place to anchor curves, and as the tunnel was planned so near the street surface as to render it impossible to lay the proper size of pipe, it was decided to lay a short piece of 30-in. flanged-steel pipe, including the two bends. This insertion has so far given no trouble.

At the time the subway was built in the Common, the City desired to lay a 24-in. high-service main across the proposed subway at West Street. As was often the case, there was no room for that size of pipe over the subway, so three bays were left in special construction, and three 16-in. pipes were laid instead.

CASTLE SQUARE.

When the South Station was built, the old roadbed of the Boston & Albany Railroad was doubled in width as far out as Back Bay Station, involving the lengthening of all the bridges. At Castle Square the City had two 30-in. pipes crossing by an overhead bridge. The widening was so planned as to permit a street to be used directly over the new roadbed. This made the thickness of the street at this point too little to permit of a larger size pipe than 20 in., so four 20-in. pipes were laid in place of the two 30-in., wye branches being used at each end. Some fear was felt that a long line so little protected might freeze, and as at that time a patented covering, composed of felt, resin, and tallow, was coming into use, one inch of this was put around these pipes. Under these pipes, to protect them from the blast of the locomotives,

PLATE XII.
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DIFFICULTIES MET IN
SUBWAY CONSTRUCTION.

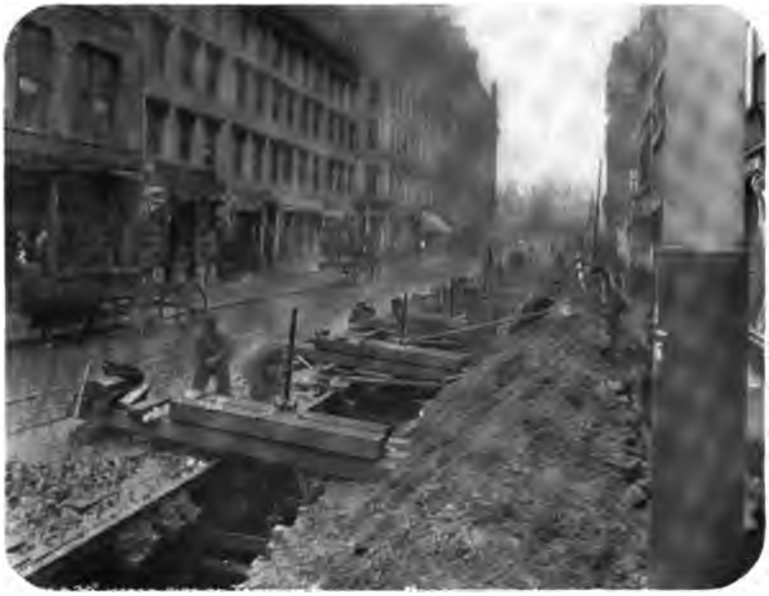

FIG. 1.
THE METHOD USED IN SHIFTING 30-IN. PIPE.

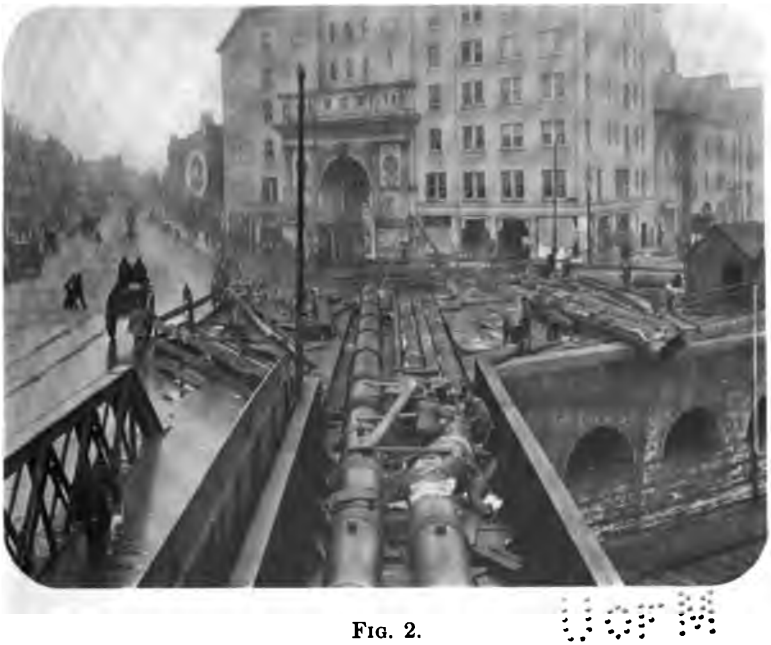

FIG. 2.
PIPING AT CASTLE SQUARE.

cement mortar was thrown, below this being a plastered wire netting. Over the bays was placed a steel plate, on which rested the roadbed composed of asphalt 1½ in. thick.

For some years observations of temperature were made at this point, but the water in the pipes never reached the freezing point. Plate XII, Fig. 2, shows the work at Castle Square about half completed.

COMPRESSED AIR TUNNELS.

The earlier pipe crossings of the harbor were made by siphons where the pipe was embedded in concrete enclosed in a heavy wooden box, and the entire siphon sunk in one piece. As changes occurred in depth or width of the channels, it appeared wiser to make these crossings safe and beyond the reach of any future disturbance. Accordingly three crossings were made in 1904 and 1905, of which two, the one at Dover Street and the one at Mystic Wharf, were in charge of the writer. As all were done under similar conditions, a description of one fits all.

The longest of the three tunnels was at Mystic Wharf, where the distance between the shafts was about 550 ft. The shafts were 60 ft. in depth. In every case a wrought-iron cylinder was sunk over the shaft location, and weighted so that it would sink well into the mud before the air was put on. The cylinder was then lined with the brick as designed, causing still further settlement. The small air lock was then put on and on the application of the air, the water lowered in the cylinder. The process of operation from this time was to excavate from 4 to 6 ft. beneath the lower flange and for 1 ft. out from the inner edge of the cylinder, and then to lay brick in its permanent position in the shaft, the cylinder being supported by its own friction. A circular row of pipes had been driven around the shaft to guide and hold it in position.

Speed is always slow on this part of the work, on account of the restricted space in which to lay brick. The shafts were 8 ft. internal diameter, the excavation was almost wholly in stiff blue clay, with some sand seams. The lines were maintained from a base line 4 ft. long, from holes bored in the bottom plate of the air-lock, piano wire being used with plumbs in water at the base of the shaft. This line was produced, and operations repeated again and again, and from this short base line, no appreciable error was found when the second shaft was opened 550 ft. away. Plate XIII shows the general plan of one of the tunnels.

The mode of procedure in tunneling was as follows: A length of 10 ft. of the upper half of the tunnel was excavated, the material being carved out easily, and the roof was then held in place by curved flanged plates supported by posts, the plates being bolted and left in place, forming the backing for the brick. The lower half of the tunnel was then removed and the bricks laid in the entire section. The men worked in 11-hour shifts throughout the work, and a speed of 5 ft. of finished tunnel per day was made. Occasionally 10 to 12 ft. would be excavated in one day. The brick lining was 1 ft. in thickness. A specially fine sand was used for the purpose of reducing leakage into the tunnel. After some months, however, all the tunnels were found filled with water. The inside of the tunnel was plastered with neat cement, no waterproofing material being used. The distance between the top of the tunnel and the bottom of the channel was 17 ft. The air-pressure varied from 18 to 24 lb., but one compressor being in service, excepting for a short time toward the end of the work. One tunnel carries a 16- and a 24-in. pipe, the other a 30-in. pipe.

It is believed that the greater safety of the pipes, the ease of making repairs, and the fact of the pipes being beyond the reach of any probable change in the channel more than compensate for the increased cost of this method over the older method referred to previously. Plate XIV, Fig. 1, shows the method of construction in tunnel.

DEER ISLAND.

Deer Island is near the mainland on the north side of Boston, and is used by the City for its penal population. The original pipes across Shirley Gut were two 8-in., laid so near together that if one broke the other was also liable to go. These were laid in 1871.

In 1896 an 8-in. pipe was laid across Shirley Gut, followed four years later by a 12-in., laid some distance away. The two types of flexible joint used in this vicinity are shown in Figs. 11 and 12. Fig. 11 design shows the style of joint in the old pipes; it resembles the old Ward flexible joint, in that the score is cut into the spigot,

PLATE XIII.
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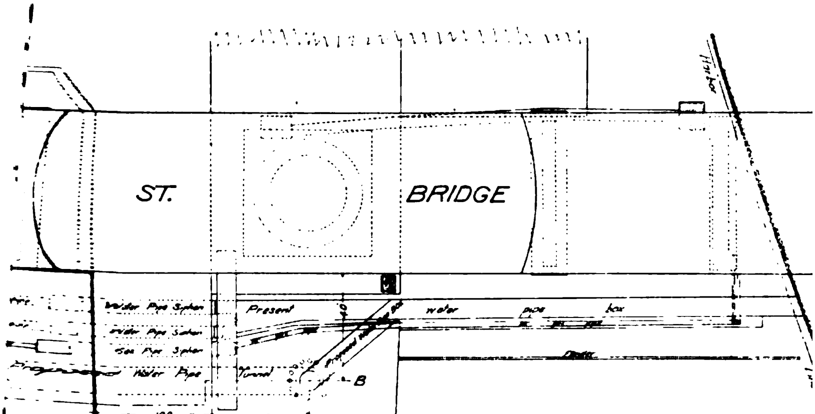
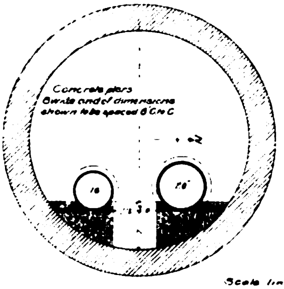
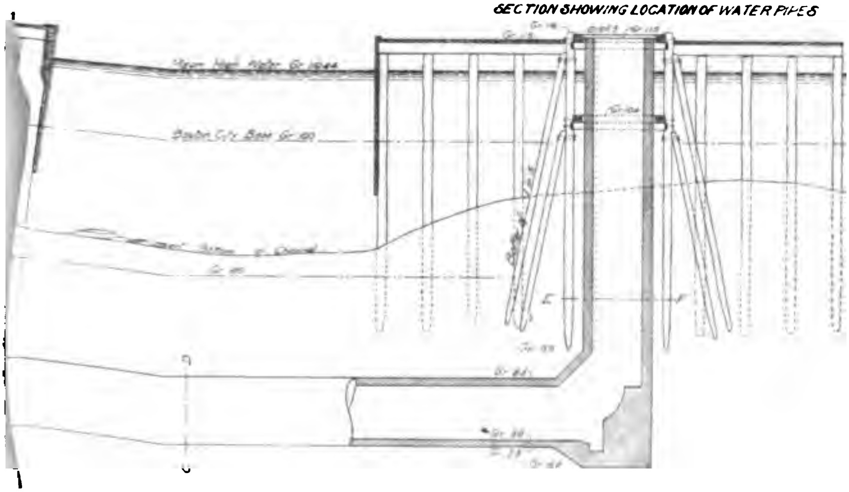


OF DOVER STREET BRIDGE
TION OF PROPOSED WATER PIPE TUNNEL
SCALE 1 in = 20 FT



Scale 1 inch = 2 Ft

SECTION SHOWING LOCATION OF WATER PIPES



UDINAL SECTION THROUGH LINE A-B

SCALE 1/4 in = 1 FT

so that whenever a change occurs in the relation of two adjacent pipes the lead emerges from within the bell. The objection to this form of joint is that when the two pipes reassume their original position, the lead is liable to be skived off. In Fig. 12 design, which has been in use in the vicinity of Boston since 1895, the lead is held within the bell and does not emerge when the pipe shifts position. In laying, the pipe was placed on rollers in a long runway on the bank, and as the distance across Shirley Gut was but about 500 ft. it was easily pulled across by a capstan arranged on the opposite shore.

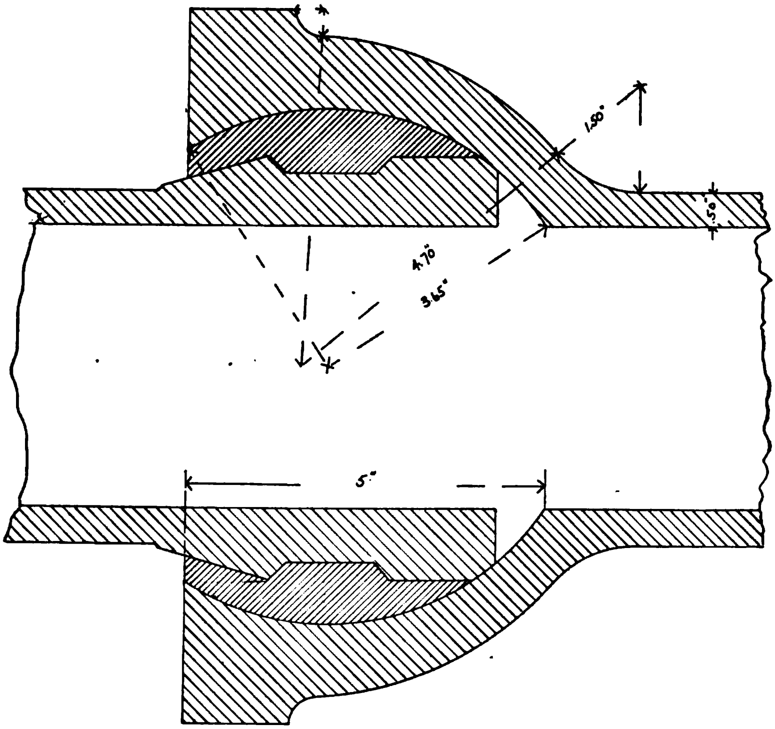


Fig. 11.
Flexible Joint with Lead on Spigot.

After these pipes were laid it was decided as a further safeguard

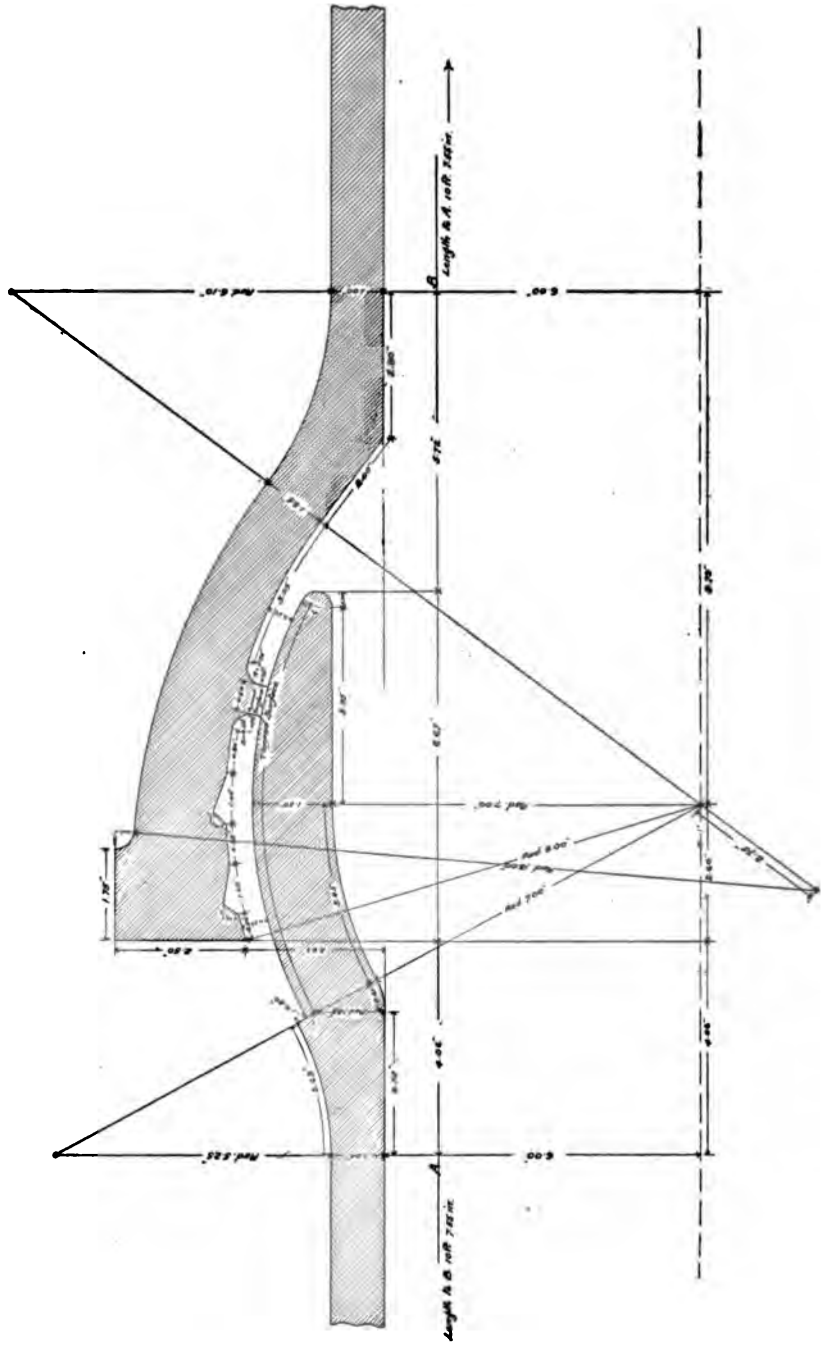


FIG. 12.
FLEXIBLE JOINT WITH LEAD IN BELL.

PLATE XIV.
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SUBWAY CONSTRUCTION.

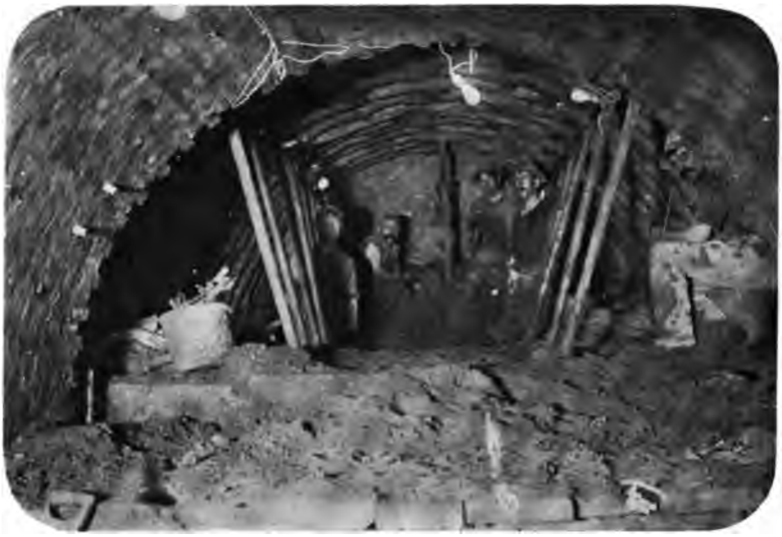
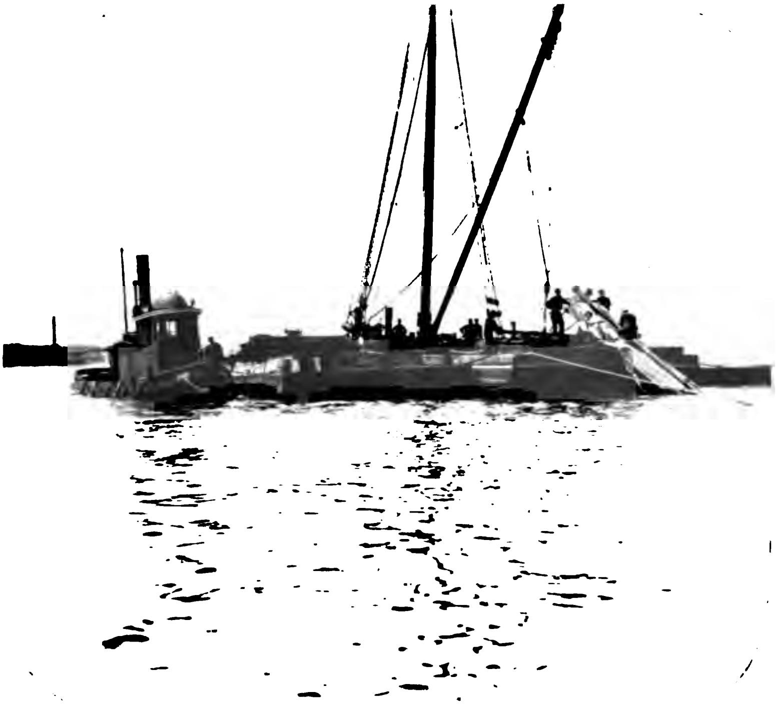


FIG. 1.
TUNNEL CONSTRUCTION.



UofM

FIG. 2.
METHOD OF LAYING PIPE TO SPECTACLE ISLAND.

to the 1 000 to 1 800 involuntary inhabitants of the island to build a reservoir large enough to hold some weeks' supply and at an elevation sufficient to feed the highest buildings. The size settled on was of two and one-half million gallons capacity, the dimensions being 138 ft. by 43 ft. on the bottom, 231 ft. by 136 ft. at the water line, and 282 ft. by187 ft. at the extreme outside path. The reservoir was so designed as to equalize the cut and fill, but was slightly sunk to avoid too high a bank, as the Government proposed to have a station near by on the island for heavy gun practice.

The material of this hill, like all the drumlins in the vicinity of Boston, is an almost impervious hardpan, and rain falling on it would remain until evaporated. The peculiar features about this reservoir were the long time required in building it, and the low cost of the the labor involved. It took six years in building, all labor except a few foremen being taken from the ranks of those who were serving their county by working with no compensation save bed and board, or, in other words, "doing time" at a city seaside resort. They therefore had no particular incentive to labor, or to turn out specially good work, although they did do so.

The hours of labor were not lengthy, three and one-half hours in the forenoon, and two and one-half or three in the afternoon. There was no opportunity on this work to actually compare the labor with high-priced or free labor on similar work. Some years ago, however, the writer did compare the two kinds of labor in laying a mile or two of pipe, and found that the efficiency of the unpaid labor was from one eighth to one tenth of the paid labor.

High-water mark of the reservoir was elevation 109 ft. above City Base, the top of the bank being at elevation 114 and the bottom of the reservoir at elevation 88. The inside slopes were 2 to 1, the outside slopes being 2½ to 1. All work in excavation was carefully trimmed to 6 in. below grade, and filled to grade with concrete of 1 : 2 : 4 mixture, the finished surface being plastered so as to present a smooth appearance. A flight of steps was constructed in order that sediment may be carried out from the bottom. No drainage pipe was provided, in order to save expense; in fact, all expense for materials was cut as much as possible.

The site was first stripped of the thin layer of loam found on the

U of M

island and the banks were built up in layers of less than 6 in. in thickness, and very thoroughly rolled when wet with a grooved roller, all large stones being removed. Up to the present time the reservoir has been filled and emptied several times, and there has never appeared to be any leakage or head behind the concrete lining, and no leakage has shown through the bank.

The overflow consists of a 16-in. pipe laid on a large block of concrete going well down into the concrete beneath the stone chips. The one pipe serving as intake and outflow is a 12-in. This was laid from the bottom of the reservoir to the gate chamber in tunnel. This tunnel was braced, in order to avoid any possible suits for damages, although it would undoubtedly have stood alone. To prevent leakage through this tunnel, it was backfilled with lean concrete.

The flow into the reservoir had to be controlled to prevent overflowing, so that the method shown of three 2-in. inlet pipes controlled by 2-in. ball cocks with 12-in. floats was adopted.

In the ordinary operation of the reservoir the check valve in the bottom of the chamber is shut by the pressure against it, water rises to the tank and flows down beyond the check valve into the reservoir. If the head in the pipes on the island drops, the reservoir acts automatically and the check valve opens. There are of course check valves on the island side of the two mains across the gut, so that if the pipes break, the reservoir would not be emptied.

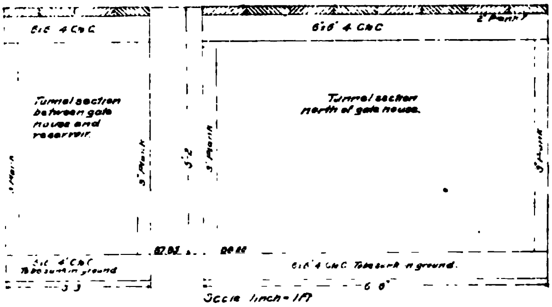
The material for the reservoir cost as follows: Cement, $3 082; paving blocks, $946; valves, $218; lumber, $474; a total of $4 720 for material, or $3 774 not including the paving blocks, which were purchased and used merely to give the slope a neater appearance. This reservoir is an example of low-priced construction where labor cost nothing and time is of minor consideration.

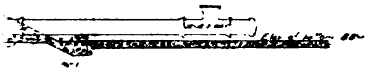
Plate XV shows the plans of the reservoir.

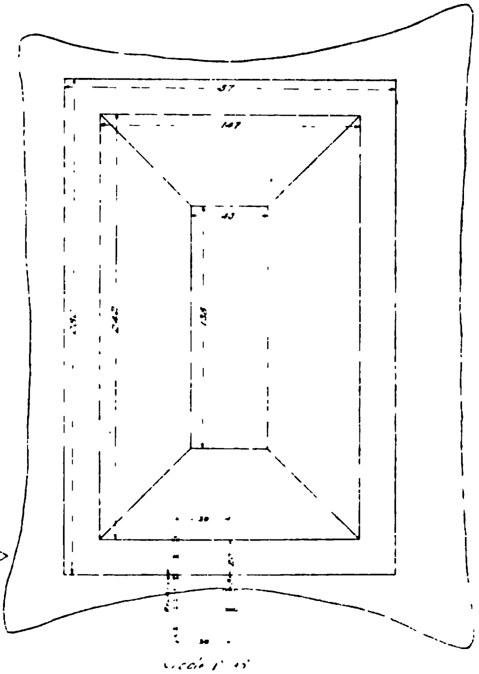
THIRTY-INCH CEMENT-LINED PIPE.

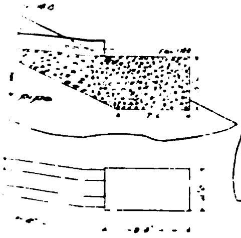
In 1900, it became necessary to remove and relay with cast-iron pipe about 850 ft. of the 30-in. cement-lined wrought-iron pipe which was laid into Charlestown in 1870. The reason for relaying was in no way caused by a failure in the old pipe, part of which is

DEER ISLAND TUNNEL.
Method of bracing.









still in use and which, when laid in unyielding soil, has given good satisfaction. In constructing this pipe three 3-ft. lengths were joined in the shop. Over both of the riveted joints a clamp sleeve of proper curve section was placed, the space between the sleeve and the outside surface of the main being filled with neat cement. These 9-ft. lengths were joined together in the trench by a close-fitting sleeve 8 in. wide. The outside of the pipe was covered with 2 in. and the interior was lined with 1¼ in. of cement. The wrought-iron composing the pipe was 0.16 in. thick, and in spots had rusted to 0.11. The cement removed seemed extremely inert.

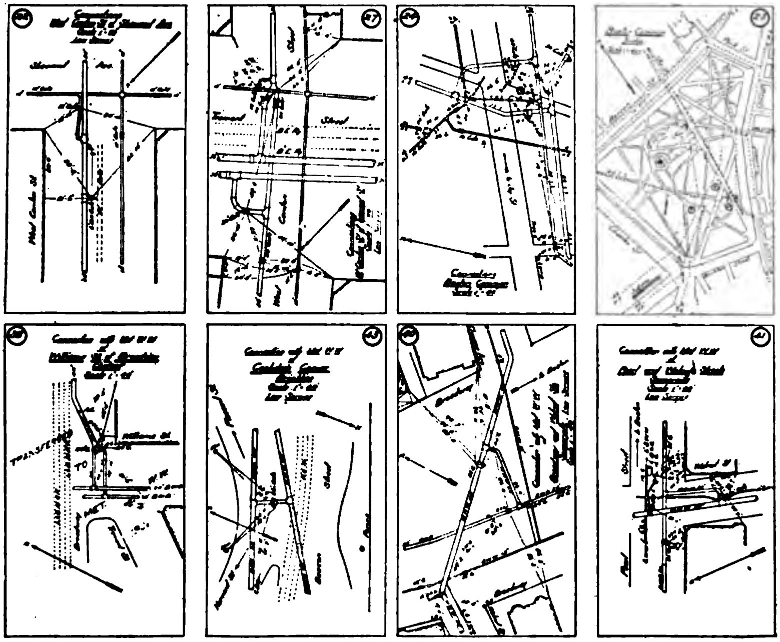


FIG. 13.
VALVE LOCATION BOOK.

PIPE TO SPECTACLE ISLAND.

During the present year a line of 4 000 ft. of 4-in. pipe, with Ward flexible joints, was laid connecting Long and Spectacle islands. The 12-ft. lengths weighed 330 lb., requiring 18 lb. of lead per joint. A cradle 115 ft. long, resting on the bottom of the harbor, was used, in which to lay the pipe, the water being 28 ft. in depth a portion of the way. Plate XIV, Fig. 2, shows the manner of laying the pipe from the scow.

Fig. 13 shows a few sheets of a book of eighty or more pages, giving locations to gates on important lines for the use of those who are compelled to find them at any time.

As some portions of the matters referred to in this paper have previously appeared in *Engineering News*, the author desires to thank them for courtesies extended in permitting the use of the same. The author is also under obligation to the Boston Transit Commission, and to Mr. Edwin C. Hayden for photographs loaned.

USES AND ABUSES OF WATER FILTRATION.

BY GILBERT H. PRATT, CHEMIST OF THE RHODE ISLAND STATE BOARD OF HEALTH.

[*Read December 11, 1912.*]

In connection with the uses of filtration of water, the author would first mention a few of the conditions which call for such treatment. For many years a town or city may have been using some water of comparatively good appearance as a supply when suddenly there appears an unusual amount of typhoid fever among the people. Investigation demonstrates that it is the water supply which is common to these cases, and bacteriological tests prove that the water of the stream is polluted. Further investigation shows that there have been some cases of typhoid in a small village upstream, which has no sewage purification, and the excreta from these cases has found its way into the water supply of the downstream neighbor. This experience — such a common one in the case of cities and towns taking their supplies from streams which have an increasing population on the watershed — leads to a full appreciation of the need of purification, and the resulting improvement in the supply with attendant betterment of the health of the community serve as evidence of one use to which filtration is put.

Another city may be enjoyin , an exceptionally good health record, especially as to typhoid fever, but the presence of a large amount of organic matter, giving the water a high color and a vegetable taste, causes criticism of the supply, and, regardless of analyses as to its sanitary purity, a large number of citizens persist in the contention that the supply is not what an up-to-date city should be furnishing, until finally it is decided to filter the water by mechanical filtration in order to get a water of better appearance. The criticism above referred to immediately ceases, and the people receive a practically colorless water with comparatively no taste in place of the old familiar " organic brew."

Thus esthetic reasons may in many cases be sufficient cause for filtration, and the resulting output certainly justifies its use in these cases.

Similar to the above instance, the presence of different algæ may be the cause of disagreeable odors and tastes which demand filtration by methods which in such cases usually require aëration in conjunction with either double slow sand filtration or mechanical filters.

Some cities or towns and numerous small private supplies have been troubled, in cases where the supply is from driven wells, by the presence of iron in the water. This iron often exists in the lower state of oxidation or ferrous condition and upon contact with the air separates from the water as a " brick dust " sediment. Such supplies as this can be purified by methods involving aëration and oxidation of the iron before filtration or in the case of smaller supplies this has been successfully done by the use of a patented double filter which utilizes sand and animal charcoal.

Many industrial processes, especially bleaching and dyeing, require water of good color, low in iron, and free from turbidity. This requirement has resulted in the installation of a large number of filter plants, and the use of filtration for these purposes has been invaluable to numerous mills of this and other countries.

A great many times filtration is resorted to largely, if not entirely, to remove turbidity from the water. This is true of many western waters.

Having thus brought out different conditions which call for the use of filtration, the author will now cite certain concrete instances of installations which have been made for the different reasons above mentioned, and will present results which will show the efficiency of such plants when properly operated in improving the objectionable features which they were primarily installed to remove.

As instances of purification of supplies which have at times, prior to the use of filtration, been the cause of typhoid fever, — or, in other words, as instances to illustrate filtration for removal of bacterial pollution, — we may cite Lawrence, Mass., and Providence, R. I. The Merrimac River receives sewage pollution at Lowell and at many other points above Lawrence, and its average bacteriological condition during 1910, to cite one typical year,* as received on to the filters, was a total count of 9 100 bacteria per c.c., and the colon bacillus, which is taken as evidence of the presence of sewage contamination, was present in all the samples examined in 1 c.c. tests. The output from the plant (old filter) showed only 57 bacteria per c.c. and the test for B. coli communis was positive in only 8.3 per cent. of the samples examined in 1 c.c. tests. This shows a removal of 99.4 per cent. of the bacteria and a very marked improvement of the conditions as to the presence of B. coli communis.

The water supply of Providence is obtained from the Pawtuxet River, and prior to the year 1906 was used without filtration. During these years there were at least two typhoid-fever epidemics which were traceable directly to contamination of the drinking supply of the city. The first was in 1882 and the second in 1888, the latter epidemic being caused by the fact that the attendants upon a case of typhoid fever had considered the river a means of quick disposal of the fecal matter of the patient.

Agitation for purification immediately followed this last epidemic, but it was a number of years before the type of filter could be settled; but finally, in 1902, the contract was let for slow sand filters, and beginning with 1906 the city was furnished with filtered water. The results were noted at once, not so much from the standpoint of color, — for as is the case with this type of filtration only a comparatively small per cent. of color is removed, — but by the freedom of the water from turbidity and sediment and by a reduction in the organic matter which had caused a marked vegetable odor and taste. Beside the visible improvement in the supply, the analytical study of the conditions before and after filtration showed the changes which were effected, and the excellent sanitary condition of the supply.

As an indication of the work which these filters have performed, I would present (Table 1) the following figures showing the average condition of the river as to appearance, color, and bacteria for four years from 1902 to 1905 inclusive as shown by bi-monthly tests made by the Rhode Island State Board of Health, and for comparison similar figures on samples taken from a tap in the city covering the same period. These figures show that during this period the distribution system and reservoir storage effected some purification as shown by the slight improvement in the appearance, a removal of 10.9 per cent. of color and 81.8 per cent. of bacteria. Tests for B. coli communis were not made by the Board at this time.

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* Massachusetts State Board of Health Report 1910, page 273.

TABLE 1.

PROVIDENCE WATER SUPPLY.

(1902—1905.)

Source.	No. of Samples.	Average Turbidity.	Average Sediment.	Average Color.	Average Bacteria per c.c.	Remarks.
Intake.	96	Slight to decided.	Considerable.	46	4,000	
Tap in city.	96	Very slight to slight.	Slight.	41	730	After reservoir system and distribution.
Per cent. removal.	—	Appreciable.	Appreciable.	10.9	81.8	

(1906—1911.)

Source.	No. of Samples.	Average Turbidity.	Average Sediment.	Average Color.	Average Bacteria per c.c.	B. Coli in 10 c.c. tested. Per Cent. of Samples.	Remarks.
Intake.	144	Slight.	Slight to considerable.	48	2,525	92	
Tap in city.	144	None.	None to very slight.	28	60	1.7	After filtration, reservoir system and distribution.
Per cent. removal.	—	Complete.	Almost complete.	41.7	97.5	—	

Similar figures are also presented (Table 1) showing the average condition of the river for six years subsequent to the use of filtration covering the years 1906 through 1911, and similar figures from a tap in the city for comparison. These figures show a marked improvement in the appearance of the water, a 41.7 per cent. of removal of color, as compared with only 10.9 per cent. due to the reservoir system prior to filtration, which would indicate 30.8 per cent. due to the filters themselves, and show a removal of 97.5 per cent. of the total number of bacteria present. B. coli communis was found to be present in 92.0 per cent. of the number of samples tested on the river, and in only 1.7 per cent. of those taken in the city during the filtration period, these tests being on 10 c.c. samples.

In the preceding tables one sample has been omitted in striking the bacterial averages for the tap in the city during the six years of filtration because of the fact that certain conditions which will be brought out later required the use of river water which affected that sample. The figures presented, therefore, are a true measure of the water of the city during filtration, and show the good work which has been accomplished in removing the bacterial pollution from the water.

The water supply in East Providence is taken from the Ten Mile River, which is a polluted stream receiving sewage from Attleboro, Mass. The condition of this river became such that in 1899, upon the recommendation of the State Board of Health, a mechanical filter plant was installed. The results have been highly satisfactory, showing a reduction from 8 160 bacteria per c.c. in the river to 33 per c.c. in the effluent, or a removal of 99.6 per cent., and complete removal of B. coli communis at all times. These analyses were of monthly samples taken the first eleven months of this year. In addition to this efficiency for bacterial removal, the plant at the same time reduced the color from 61 in the case of the raw water to 6 in the filtered water, or a removal of 90.1 per cent.

From the above, it has been plainly shown what can be accomplished by either slow sand filtration or mechanical filtration in removing dangers from bacterial pollution of water supplies, and it would seem to indicate very little choice between the two systems from the standpoint of removals effected, but with the advantage in favor of mechanical filtration from the standpoint of removal of color from water high in organic material. I will not attempt to go into a discussion of the relative merits of these two systems of purification, as that is not the subject of this paper, but I will simply say that each system is efficient under certain conditions, and local conditions should, in all instances, assist in the selection of one or the other method.

As an instance to illustrate the use of filters for removal of color, I would cite the case of the plant at East Warren, R. I., where during 1911 the color in the raw water averaged 74, and was reduced by the mechanical filters to 11, or a removal of 85.1 per cent. This plant is an illustration of a case where slow sand filters, while they would have delivered a sanitary output, in a short time would have experienced trouble from algæ present, and the output would not have given satisfaction to the consumers because the water would still have been highly colored instead of being practically colorless as is the present condition.

At Newport, R. I., there is a mechanical filter plant which has been installed to serve a double purpose of removing bacterial pollution and also to remove odors due to algæ. This is an up-to-date plant in every way, using a system involving aëration, coagulation, and sedimentation, followed by filtration and then disinfection of the supply with hypochlorite of lime. The color of this water is comparatively low, and the resulting output is of good appearance, when the plant is being operated up to its possibilities, and the effluent is largely free from algæ and odor troubles. Likewise, the water is reduced as to bacterial count to a point where it is practically sterile.

Next passing to the question of concrete instances of installations for the removal of iron, I would mention the plant at Marblehead, Mass., where by the use of aëration and filtration through sand the color of the water is improved from a rusty appearance to a practically colorless water, and the iron is reduced from 4.70 parts per million to .06 parts, or a removal of 98.7 per cent. One installation has come under my personal observation where the particular apparatus above referred to, which employs a double-cylinder filter using sand and animal charcoal, showed a removal of iron from 8.00 parts to .10 parts, or 98.75 per cent. removal, with accompanying improvement in the appearance of the water.

In connection with the use of filters in the purification of water for industrial purposes, I would say that I have been in touch with a number of installations where mechanical filters have been installed of different types which, when properly operated under proper supervision, turn out a product which gives entire satisfaction and shows purification in every way comparable with the results above given.

In treating the second part of my subject, namely, the abuses of water filtration, I would call attention to a number of ways of abuse which might lead to criticism of the whole idea of filtration, but in citing these cases where such abuses have occurred, for obvious reasons I will refrain from naming the installations in most cases.

In the case of slow sand filtration, one would consider it an abuse to attempt to purify a water high in algæ content which would result in clogging of the beds and a general upsetting of operating conditions at the plant. Of course, double slow sand filtration, especially if in connection with aëration, would qualify this previous statement, as aëration and a pre-filter would put the water in condition where it could be handled by the secondary filters, but where aëration followed by coagulation and sedimentation and filtration by mechanical filters would obviate all of the trouble due to clogging of the beds, it would seem as if it was abusing the at times satisfactory method of slow sand filtration to attempt to handle such a water by simple slow sand filtration.

It would also seem an abuse of this method to use it in connection with filtration of highly colored water, which would subject the method to criticism on account of the unsatisfactory appearance of the output.

Another abuse of this method in connection with operation of the filters is too quick changing of rates of operation, which tends to disturb the bacterial action going on at the surface with attendant poor results from an analytical standpoint. Also attempting to overcrowd the filters by running at too high rates is a practice which is sometimes met with, which results in diminution of the efficiency of the plants.

A slow sand filtration plant which would handle a given water satisfactorily might, as was the case in Providence, be installed without covering the beds. Such an installation as this in this section of the country is certainly an abuse of the method, for the result invariably would be what was found in Providence, that as soon as a hard winter struck the plant the beds would become covered with ice and it would be impossible to get at the surface to clean without removal of the cakes of ice. This condition occurred in Providence for a short time during February, 1907, finally necessitating opening the river gate, and the use of raw water for about two weeks or so before the weather moderated and before the ice could be removed. This experience resulted in steps immediately being taken to cover the beds, and this experience should serve as a lesson against such open installations in this section of the country.

In connection with slow sand plants, it is necessary to have competent help administering the plant, and one of the easiest ways to abuse a plant is to put it into the hands of inexperienced operators.

The above remark about labor in connection with plants is especially true in the case of mechanical filters where the supervision must be particularly close and where tests for color and alkalinity must be made to regulate the doses of chemicals used.

One of these plants which has come under my observation had operated for a number of years satisfactorily, turning out a water which had given entire satisfaction in connection with work in a bleachery. When I was consulted with regard to difficulties which were occurring, I found that the only trouble was that the parties in charge did not have an understanding of the question of alkalinity control of the plant, and the residual alkalinity of the effluent had dropped to a point where the water was passing the plant at times in an acid condition, or at best with an extremely low alkalinity, resulting in after-coagulation in the vats and throughout the system. This condition had been caused by the fact that a certain mill above them had been discharging a larger amount of acid wastes in the river than at the time their formula for operating was figured for them. Not knowing how to vary the dose from time to time, they had stuck to the old formula with the resulting poor work until corrective measures were taken. The addition of alkalinity to the water put the plant back into its former good condition.

At another installation concerning which I had been consulted, I found another condition which was causing trouble. The responsible man in charge of the plant for some reason or other was assigned to night duty, and he was attempting to make his control tests for color and alkalinity at night by artificial light. This, of course, gave far from accurate results. Another trouble at this plant was that the one man was expected to operate the flow of chemicals from the tanks which were located in the pump house and at the same time attend to washing the filters in a filter house which was located about one eighth of a mile away. This spreading out of the plant made it impossible for the lone operator to properly attend to the dosing, and the result was that the flow of chemicals varied from time to time, with resulting poor output from the plant. Here, too, I found trouble in connection with the dosing, for the formula they were using to operate by had evidently been recommended without a knowledge of the water to be handled, and they too were operating with a too low residual alkalinity.

At another plant this same trouble as to a low residual alkalinity was found to exist, and the output contained undecomposed sulphate of alumina. Investigation showed that this operator was using an indicator solution many times too strong, and the alkalinity tests which he was obtaining were absolutely inaccurate. They also were not showing intelligence with regard to the necessity of increasing the doses of chemicals to meet varying conditions in the raw water. Corrective measures, recommended by the State Board of Health, and instruction of the operator, has resulted in this plant turning out one of the best outputs in our state at the present time.

At still another plant the biggest difficulty discovered when troubles arose seemed to be with the application of the chemicals, which in this plant required an extremely close control on account of an influence on the color of the filtered water as the residual alkalinity became too high. The engineer who was employed when this plant started was a man who had been for years pumping water out of the reservoir under the old system, and he could not be made to realize that careful supervision was necessary, and grossly neglected controlling the flow of the chemicals. These operating troubles immediately ceased when a new, competent engineer was put in charge of the plant.

The effect of an abnormal amount of organic matter or algæ in comparison with the color of the water sometimes has resulted in an under dosing with coagulant, as this additional amount of organic matter has seemed to prevent proper coagulation with resulting incomplete removal of the constituents which it was intended to remove, and the effluent has contained alumina and abnormal amounts of color and algæ. Proper dosing in view of the above-mentioned conditions has resulted in excellent work from this plant.

Another abuse is oftentimes attempting to operate a plant, with every possibility for good results, by methods which some man of limited experience may have used at some other plant, meeting entirely different conditions. Such cases have occurred under my observation, but have been capable of adjustment when instructions have been given which had in mind the type of plant and the raw water to be handled.

In connection with the operation of plants of the mechanical type, it is essential that the night man should be one who can be depended upon to stay awake, as a nap for an hour or two may result in throwing the whole operation of the plant out of adjustment for several hours. I have had my experience with this trouble.

Having thus brought out the conditions which call for filtration of water supplies and having shown the good results obtained with certain installations, I have also attempted to point out a number of ways in which filtration plants are at times abused. One or more instances of abuse are sometimes the only cases of filter plants coming to the attention of some people who immediately condemn the possibilities of the whole proposition of water purification on this meager knowledge.

I would take this opportunity to warn you water-works men against such conclusions from knowledge of some plant or plants which may not be doing all that has been claimed for them. I would also particularly caution that you do not take the cases of abuse which I have mentioned as indicative of any lack of confidence on my part in the ability of plants to purify water satisfactorily when the following essential points have been observed: first, have the choice of the system and the general outline and construction of the plant in the hands of competent consulting engineers who are experts in these matters; next, having obtained the plant properly constructed and designed to handle the water to be filtered, obtain the best possible men to oversee and run the plant after instruction from competent specialists, and if trouble occurs, call in advice to straighten out the difficulty instead of experimenting blindly; and last, throughout the whole operation of the plant bear in mind that you are handling an efficient machine capable of results, and not an automatic affair which can be left to its own resources.

DISCUSSION.

MR. CHARLES W. SAXE.* I have been troubled quite a little with algæ during the summer months. The principal trouble has been from the stoppage of the beds, due, I think, to the use of too little alum, and I increased the amount to remedy that difficulty. Otherwise the results have been excellent. The plant is now delivering practically sterile water, as Mr. Pratt says. I very seldom find coli in the raw water, and I have never yet found it in the effluent.

The efficiency of a plant of the rapid type most assuredly depends upon the even running of the coagulant in proper proportion to the flow of raw water. Slap-dash doses of the coagulant do not prove out very well, especially with water containing algæ, dead or alive. For uniform bactericidal action, the hypochlorite solution must also be run at an absolutely even rate.

Outside of these necessities and the correct estimation of dosings, there are few other vital things for efficiency.

MR. R. S. WESTON † (*by letter*). Mr. Pratt, in his capacity of chemist of the Rhode Island State Board of Health, has had perhaps a better opportunity to observe the operation of various sorts and kinds of water purification plants than any other man in a similar position. While there are practically no muddy rivers in Rhode Island, there are many polluted ones, besides sources which are contaminated with growths of algæ, other microscopic plants and animals, and with the wastes of the most densely populated state in North America. That Mr. Pratt has not neglected his opportunity, this paper is an evidence.

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* Chemist in charge of Filtration Plant, Newport, R. I.

† Sanitary expert, Boston, Mass.

It is well to emphasize again Mr. Pratt's advice as to the necessity of designing a plant to suit the water to be purified and not in accordance with some general "cure-all" theory which may have no bearing in the particular case; also his insistence upon careful and responsible operators of filters and the analytical control thereof. There are few states, however, where advice is so freely and promptly given as in Rhode Island, and to the writer's knowledge this efficiency has kept at least one filter plant from failure.

Mr. Pratt mentions many of the abuses of filtration and has covered the ground. In connection with the removal of algæ, however, he does not mention the use of intermittent filters such as were used at Springfield. Here, as is well known, experiments demonstrated that any single system of filtration was inadequate to remove taste and odor. It was because of this experience that the writer thought that intermittent sand filters with aëration were best suited for the purification of the Newport supply, grossly contaminated with algæ, and he still believes that without the use of hypochlorite the operation of the present mechanical filters would be impracticable, although with it they present some advantages.

The writer had one experience with double filtration through sand and charcoal in 1895, at Asbury Park, N. J. These filters were used for the deferrization of the water, and it was found that at times iron was absorbed by the charcoal filter and at times given off. The charcoal was replaced with sand, and results were obtained equal to the best — and far better than the average with charcoal. New charcoal, however, removed more iron than new sand.

Most water purification experts spend half their time in correcting the errors mentioned in this timely paper, which, if read and taken to heart as it deserves to be, will tend to prevent many of the mistakes of the past and conserve the public energy in the future.

Mr. H. W. Clark[*] (*by letter*). I have little comment to make in regard to the main part of Mr. Pratt's paper. We all know at the present time that there is a place for slow filters and a place for rapid filters with the use of coagulants, and the paper brings out forcibly many points in regard to correct operation of filter plants.

I think, however, that he is incorrect in his statement that it is " an abuse to attempt to purify [by a slow sand filter plant] a water high in algæ content, which would result in clogging of the beds and a general upsetting of the operating conditions at the plant." While I have had a considerable acquaintance with reservoirs in which enormous growths of microscopical organisms occur from time to time, the two most prominent in this respect in my mind are the Ludlow Reservoir, a part of the water supply of Springfield, Mass., and the reservoir of the water supply of South Norwalk, Conn. Both of these waters have been successfully and economically filtered by slow sand filter plants; that at Ludlow by single sand filters, and that at South Norwalk by double sand filters. Experiments made at Ludlow by the State Board of Health, and afterwards by the Springfield Water Board, with Fuller and Gray as consulting engineers, ten or more years ago, showed clearly that sand filters were much more efficient in the removal of organisms, tastes, and odors than mechanical filters when handling such waters, and following these experiments, the sand filters mentioned above were installed at Springfield, and about the same time the sand filters were built at South Norwalk, Conn. Both plants have been absolutely efficient and economical when filtering two reservoir waters seriously polluted with microscopical organisms.

Mr. Pratt says also that it is " an abuse of this method [slow sand filtration] to use it in connection with a highly colored water on account of the unsatisfactory appearance of the output." As a matter of fact, this statement needs some qualification. Two of the most highly colored waters purified by filtration in New England are the reservoirs just mentioned. At times in the summer months, the colors of these reservoirs approach or exceed 100, but owing to the nature of this coloring matter and the presence of iron in the water, more than 80 per cent. of it is often removed by single slow sand filtration, and at South Norwalk, double filtration produces a practically colorless water. With the ordinary highly colored river or swamp water, Mr. Pratt's statement is, of course, much more true.

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[*] Chemist, Massachusetts State Board of Health.

Mr. George C. Whipple[*] (*by letter*). The writer has been very much interested in Mr. Pratt's paper. Papers of this character need to be published about once in so often in order that the importance of proper operation of filters may be kept fresh in our minds. One of the things that sanitary engineers most lack is adequate information in regard to the results obtained by different filter plants under the special conditions under which they operate. The New England Water Works Association has done a good work in standardizing reports of various kinds, and the writer would be glad to see this subject taken up by an appropriate committee, and studied with a view to standardization of the results of filter operation.

One point mentioned by Mr. Pratt is of particular interest, namely, that the filtration of the Pawtuxet River water by the Providence sand filter removes the vegetable odor of the water, although it does not decolorize it. This suggests that the vegetable odor may be due more to the suspended and collodial matter than to the organic matter in solution. If Mr. Pratt could furnish further information in regard to this matter, it would be of interest to many of us.

Mr. Pratt (*by letter*). Taking up a few points raised by Mr. Clark, I would say with regard to his comments upon my remark in connection with removal of color, that I had in mind handling a reservoir which at times goes up to 180 in true color, and in this case slow sand filters were considered for a time as a means of purification. I consider that it would have been an abuse of slow sand filtration to have tried it with this water or with waters even approaching 100 in color. I think also that Mr. Clark unintentionally misleads somewhat in his mention of 80 per cent. color removal by slow sand filtration. My experience in removal of true color has been that 30 to 40 per cent. is considered extremely good for the method. Of course, with algæ-infected or iron-bearing waters having a high apparent color in comparison with the true color, removals of apparent color might easily give higher figures.

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[*] Professor of Sanitary Engineering, Harvard University, and Consulting Engineer, New York.

As to Mr. Clark's criticism of my statement in regard to the treatment of algæ-infected waters, I would say that, in my complete statement on this matter, I was careful to state that the use of mechanical filters for this purpose should be in conjunction with aëration, coagulation, and sedimentation, and with this system efficient work in removal of color, odor, and taste can be accomplished. Also, I stated that double slow sand filtration especially in connection with aëration might be used. When making the statement that single slow sand filtration would not be efficient I had in mind statements to be found in the reports of the Massachusetts State Board of Health for 1901 and 1905, in connection with the Ludlow Reservoir of the Springfield supply, and there, if I am not mistaken, the position of that board as the result of experimentation was very conservative as to the ability of single slow sand filtration to handle this water at times of extreme algæ content. In fact, they advised against the use of this water as a supply even after filtration. I also had in mind accounts of clogged beds at South Norwalk, Conn., which had come to my attention. If Mr. Clark has now been successful in accomplishing good work at South Norwalk it bears out my statement that double slow sand filtration might be efficient in the case of "algæ" waters, and if the Ludlow Reservoir water has been efficiently handled by single slow sand filters, I think that with waters of that type such a case would be the exception rather than the rule.

With regard to the point raised by Mr. Whipple as to the removal of vegetable odors by the Providence filters, I would say that while these odors are reduced very perceptibly, the filtered water still has a distinct vegetable odor practically all the time. I think the point raised by Mr. Whipple that the reduction is possibly due to removal of suspended and colloidal matters may, in part, account for the reduction, although I think that some of the improvement is due to the reduction in the organic matter in solution, which is materially reduced by the filters as shown by albuminoid ammonia tests and oxygen consumed determinations, as well as by the color removal of 30.8 per cent.

CONSTRUCTION OF ARCHED MASONRY DAM AT LAS VEGAS, NEW MEXICO.

BY WILLIAM T. BARNES, CHICAGO REPRESENTATIVE OF METCALF AND EDDY, CONSULTING ENGINEERS.

[*Read December 11, 1912.*]

Las Vegas, the second largest city in our newly adopted state of New Mexico, is situated in the northeastern part of the state along the foothills of the Rocky Mountains, on the Pecos-Arroya and Gallinas rivers, at an elevation of about 6 500 ft. above sea level.

The census of 1910 showed a population of 7 300 as against 6 320 in 1900. The future population, dependent on conditions other than local ones, is difficult to forecast.

The main line of the Atchison, Topeka & Sante Fé Railroad passes through the eastern portion of the city and makes Las Vegas one of its principal division points. It is therefore an important railroad center, distributing supplies to a large tributary area, shipping in turn the products of a large rural district.

The agricultural interests are important, and with the inauguration of large irrigation projects which have already been undertaken by private enterprise, rapid progress should be made in the development of the natural resources of this community. It is anticipated that large beet sugar industries and other industrial enterprises will follow the introduction of irrigation works. It will not be surprising, therefore, if the next decade shows a more rapid increase in the population of this city than did the last.

Las Vegas has already adopted many modern ideas of city planning. In the newer part of the city the houses are built upon substantial lines, well set back from the street on large lots, surrounded by handsome and well-kept lawns dotted here and there with rapid-growing trees.

Although the finances of the city have not as yet permitted of building modern pavements to any considerable extent, the entire city is well provided with modern granolithic sidewalks separated from the curb by wide areas of sod, in which are planted quick-growing shade trees, thus presenting a very attractive and enterprising appearance.

WATER SUPPLY.

Water is supplied to the community by the Agua Pura Company. The source of the supply is the Gallinas River at a point about nine miles north of the city, in the narrow confines of the Gallinas Cañon. The Agua Pura Company is also a dealer in ice, which it furnishes not only to the local community, but also to the Atchison, Topeka & Santa Fé Railroad, the needs of which it supplies for several hundred miles in either direction from Las Vegas. It has built nine dams in the bed of the Gallinas River for the purpose of ice production. In one of the reservoirs thus produced, known as No. 8 reservoir, is located the water-works intake. From this intake the water flows through an open canal along the borders of the reservoir, for a distance of one-half mile, where it enters a small settling basin, where racks and screens protect the inlet to the main supply pipe. From this point, which is at an elevation of 410 ft. above the general city level, the water flows 5.1 miles through a 12-in. pipe to a distributing reservoir two miles north of the city and at an elevation of approximately 281 ft. above the city level. From this reservoir the water is distributed to the pipe system of the city by two circuits, thus insuring the city ample pressure, and safety in case of need of repairs to either of these pipe lines.

DRAINAGE AREA.

The drainage area tributary to the intake is about 90 sq. miles, as determined from the topographical maps of the United States Geological Survey.

RECORDS OF RAINFALL.

With exceptions during the years 1890 and 1891 only, the government record of monthly and yearly precipitation in the city of

TABLE 1.

MONTHLY AND YEARLY PRECIPITATION, EAST LAS VEGAS, NEW MEXICO.*

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
1892	1.22	0.07	1.72	0.41	0.54	1.01	2.28	0.79	0.48	1.31	0.05		
1893	0.18	1.06	0.07		1.50	0.25	5.64	6.97	3.87	0.04	0	0.31	19.99
1894	0.10	1.66	0.04	0.54	2.53	2.82	2.89	4.05	1.22	0.08	0	0.28	16.21
1895	1.00	1.85	0.30	0.52	4.02	1.98	6.85	5.32	T	1.12	0.88	0.82	24.66
1896	0.19	0.32	0.83	1.00	0.11	2.02	3.87	2.13	4.38	4.35	0.02	0.51	19.73
1897	0.69	0.70	1.43	0.37	6.63	1.23	1.18	3.29	0.79	1.94	0	0.59	18.84
1898	0.51	0.21	0.49	1.41	1.04	2.74	4.63	2.97	1.29	0.33	0.57	0.80	16.99
1899	T	0.73	0.70	0.21	0.40	2.65	7.09	0.17	2.87	0.52	0.43	0.09	15.86
1900	0.19	0.25	0.59	2.25	1.87	3.59	2.70	2.23	4.27	1.98	0.30	0.46	20.68
1901	0.27	0.70	0.14	1.17	5.55	0.19	3.70	4.95	2.00	1.40	1.78	0.30	22.15
1902	0.10	0.10	0.01	0.06	1.95	0.30	1.91	1.83	1.33	0.47	0.79	0.93	9.78
1903	0.07	1.42	0.13	0.52	0.22	6.24	1.41	3.57	1.11	0	T	0.12	14.81
1904	0.20	0.20	T	0.24	0.97	3.20	4.95	0.68	6.07	1.08	0.05	1.10	18.74
1905	1.45	1.84	2.13	3.07	2.04	1.56	1.70	1.34	4.25	0.48	3.32	0.68	23.86
1906	0.04	1.02	0.47	2.17	1.08	2.80	7.82	1.97	1.86	1.67	0.86	1.32	23.08
1907	1.57	0.01	0.07	2.13	2.57	0.77	5.57	3.30	0.22	0.82	0.77	0.20	18.00
1908	0.14	1.05	0.05	1.12	0.68	1.13	2.71	9.24	0.06	0.76	0.96	0.26	18.16
1909	0.17	0.49	1.00	0.50	0.51	0.51	1.53	5.99	3.91	0.76	0.19	0.44	16.00
1910	0.16	0.30	0.61	0.98	0.13	0.31	2.48	3.72	1.08	0.85	0.45		11.07
1911	0.11	1.33	0.18	0.93	2.41	2.44	3.55	2.30	0.68	2.83	0.30	0.93	17.99
Average	0.42	0.77	0.55	1.03	1.84	1.89	3.72	3.34	2.09	1.14	0.59	0.56	18.00±

* From Weather Bureau Reports, New Mexico Section.

TABLE 2.

MONTHLY AND YEARLY PRECIPITATION, GALLINAS PLANTING STATION, NEW MEXICO.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
1908	0.56	1.53	1.30	3.23	1.05	0.58	5.10	5.71	0.28	1.09	1.13	0.44	22.00
1909	0.69	0.61	1.54	0.55	0.66	1.71	5.11	6.98	2.86	1.07	0.97	0.66	23.41
1910	0.62	0.76	0.65	1.63	1.54	2.49	5.59	3.96	1.86	1.27	0.69	0.42	21.48
1911	1.00	1.91	0.72		2.54	1.20	9.01	2.38	0.61	3.42	0.82	0.98	24.59
Average	0.72	1.20	1.05	1.80	1.45	1.49	6.20	4.76	1.40	1.71	0.90	0.63	22.37

TABLE 3.

MONTHLY AND YEARLY PRECIPITATION, HARVEY'S UPPER RANCH, NEW MEXICO.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
1910	1.42		1.18	2.70	1.29	2.31	3.87	6.56	1.92	2.43	0.87	1.60	26.15
1911	1.20	3.04	2.03	2.13	2.70	3.80	8.32	3.08	2.05	6.86	1.20	1.68	38.09
Average	1.31	?	1.61	2.41	2.00	3.05	6.10	4.82	1.98	4.65	1.04	1.64	32.12

Las Vegas is continuous since the year 1889, as recorded in Table 1. From these records it appears that the average yearly rainfall is about 18½ in., the maximum being 24½ in., the minimum slightly less than 10 in. The bulk of the precipitation occurs during the so-called "rainy season," which includes the months of July and August, and sometimes parts of June and September.

Records of precipitation were kept at the Las Vegas Hot Spring from June, 1898, to July 1903, but the omissions in the records are so frequent as to prevent their satisfactory use.

At the Gallinas Planting Station in the Gallinas valley, a few miles above the water-works intake, the records have been systematically preserved since January, 1908, as recorded in Table 2, while at Harvey's Upper Ranch near the headwaters of the Gallinas River the records, with exception of one month, have been kept with regularity since January 1, 1910, and are recorded in Table 3.

The short periods during which the records have been maintained prevents the drawing of accurate conclusions, but are sufficient to show that the amounts of precipitation increase with the elevation, especially during the winter and spring months.

This increased precipitation is mainly in the form of snow, which melts gradually during the spring months, the run-off accordingly tends to be more evenly distributed during the spring and early summer.

YIELD AND ITS VARIATION.

The United States Geological Survey has maintained a gaging station on the Gallinas River at the Las Vegas Hot Springs about 7 miles above the city of Las Vegas and about 2 miles below the intake of the water works, since August, 1903, and these records are available to and including the year 1910.

The records for the year 1904 show that, prior to the storm and flood September 29 to October 1, there was practically no flow in the stream, and after the flood subsided there was but a slight flow.

In Table 4 are recorded the minimum and mean rates of flow in million gallons per day for each month, and by years from 1905 to 1910 inclusive. From this table it appears that there have

TABLE 4.

DISCHARGE OF GALLINAS CREEK AT HOT SPRINGS, N. M., SIX MILES ABOVE LAS VEGAS, N. M.*

	Minimum Rate of Discharge, Mil. Gal. Day						Mean Rate of Discharge, Mil. Gal. Day.					
	1905.	1906.	1907.	1908.	1909.	1910.	1905.	1906.	1907.	1908.	1909.	1910.
January	7.7	2.6	4.6	0.8	1.2	1.2	7.7	5.9	8.8	1.9	2.8	3.2
February	7.7	5.2	9.0	0.8	1.2	1.2	25.8	7.2	9.6	3.6	2.6	2.8
March	36.8	9.0	9.0	2.3	2.2	3.2	60.3	16.7	17.8	4.6	7.5	13.8
April	48.4	33.2	16.1	2.3	3.2	6.8	114.2	63.7	28.1	19.0	15.1	19.7
May	78.1	41.3	35.5	12.9	9.7	3.2	133.0	71.0	59.0	17.7	15.9	14.1
June	12.9	5.2	9.0	2.6	1.3	0.2	40.9	20.3	41.3	6.9	4.3	1.3
July	7.7	5.2	6.8	2.6	1.3	0.2	11.2	24.8	16.0	10.1	7.1	3.2
August	7.7	9.0	4.6	18.8	4.5	1.2	17.2	14.0	17.6	41.9	21.1	8.0
September	3.9	5.2	4.6	3.2	0.2	0.2	9.0	9.5	14.7	7.9	26.8	1.5
October	1.3	1.3	0.0	0.0	0.0	0.2	2.3	11.0	1.1	0.5	3.8	0.2
November	1.3	9.0	0.8	0.2	0.2	0.2	20.7	10.1	2.0	0.9	3.0	0.2
December	7.7	9.0	2.3	3.2	1.2	0.2	12.1	28.4	2.3	3.2	2.4	0.2
For year	1.3	1.3	0.0	0.0	0.0	0.2	37.3	23.2	18.2	9.8	9.4	5.7

See Water Supply and Irrigation Papers as follows:

Paper No.	174	210	248	248	268	288
Page	115	98	137	137	95	127

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* Gaging station is located two miles below intake of water works, and these flows do not include that diverted for water-works purposes.

been a number of occasions when the flow at this point would have been insufficient to materially augment the water supply. In fact, the records of the years 1904 and 1910 clearly indicate that additional storage was absolutely necessary in order to secure a permanent water supply.

WATER CONSUMPTION.

No facilities exist for accurately determining the amount of water consumed, as the supply is wholly by gravity without meters on the main supply lines. From such records as have been obtained from time to time of the flow in the open canal, it is believed that the maximum rate of consumption is considerably in excess of 2 000 000 gal. per day, and that the average daily consumption is in the neighborhood of 1 500 000 gal. per day. During the season when large volumes are used in " irrigating " the lawns and gardens, the daily consumption is probably about 1 750 000 gal.

QUALITY OF WATER.

Draining a rocky mountainous region, flowing through long and narrow gorges, with precipitous bluffs on either side, the Gallinas River naturally supplies very clear and pure water. In times of freshet, however, the water finds its way to the stream with such rapidity that large volumes of gravel, clay, and alluvium are carried in suspension. These freshet conditions are, however, confined in the main to one or two periods of time, of two to three weeks each, during the " rainy season."

AVAILABLE MEANS OF SAFEGUARDING THE SUPPLY.

In order to improve the quality of the water supply, two practicable methods were considered, — filtration and storage.

FILTRATION.

Filtration offered some advantages over simple storage of water. Such a plant could be located within easier reach of the city, might reduce the hazard of pollution, the suspended matter in the water at certain seasons, the possibility of taste and odor from algæ or other forms of growth, and might effect a saving in initial expenditure.

On the other hand, the filter plant had the disadvantage of not providing additional storage to supplement the minimum stream flow, a matter of increasing importance as the population and demand for water grows, and unfortunately involved far greater cost of operation and maintenance than did the project for a storage reservoir.

STORAGE.

Two sites for a storage reservoir were available in small lateral cañons tributary to the Gallinas River, one at a point abreast of Placita Llano, the other in a cañon or valley near the "Hot Springs," owned by the Cañon Lime Company.

Although the first location offered a good dam site, the comparatively steep slope of the cañon prevented the development of ample storage except at great expense.

The valley belonging to the Cañon Lime Company was admirably suited for a reservoir. Its mouth, a cañon through a quartzite ridge, running in a generally northerly and southerly direction, formed a natural site for a dam. The slope of the bed of the valley was sufficiently flat so that the basin formed by the dam was well adapted to a storage reservoir, and of much importance was the fact that this valley had no stream running through it except that created during the rainy season, by the rain falling within a very small watershed.

The drainage area was small, only 3.0 sq. miles. Therefore the run-off from it was practically insignificant, thus making it possible to collect and divert the storm flows upon it in a channel built around the edge of a reservoir, discharging them below the site of the dam and preventing the fouling of the clear water stored in the reservoir. This reservoir could be filled by means of a small canal or ditch, having an approximate capacity of 10.0 cu. ft. per sec., which would carry the water diverted during periods when the waters are clear, thus making available at all times a clear water as well as affording ample storage capacity.

STORAGE RESERVOIR ADOPTED.

In view of these advantages, the storage reservoir was adopted in preference to the filtration plant, and the dam was built at the mouth of the Cañon Lime Company's cañon.

DESIGN OF DAM.

In designing the dam, three types were considered, — a straight gravity section; the hollow reinforced dam of the Ambursen type; and the arched masonry type.

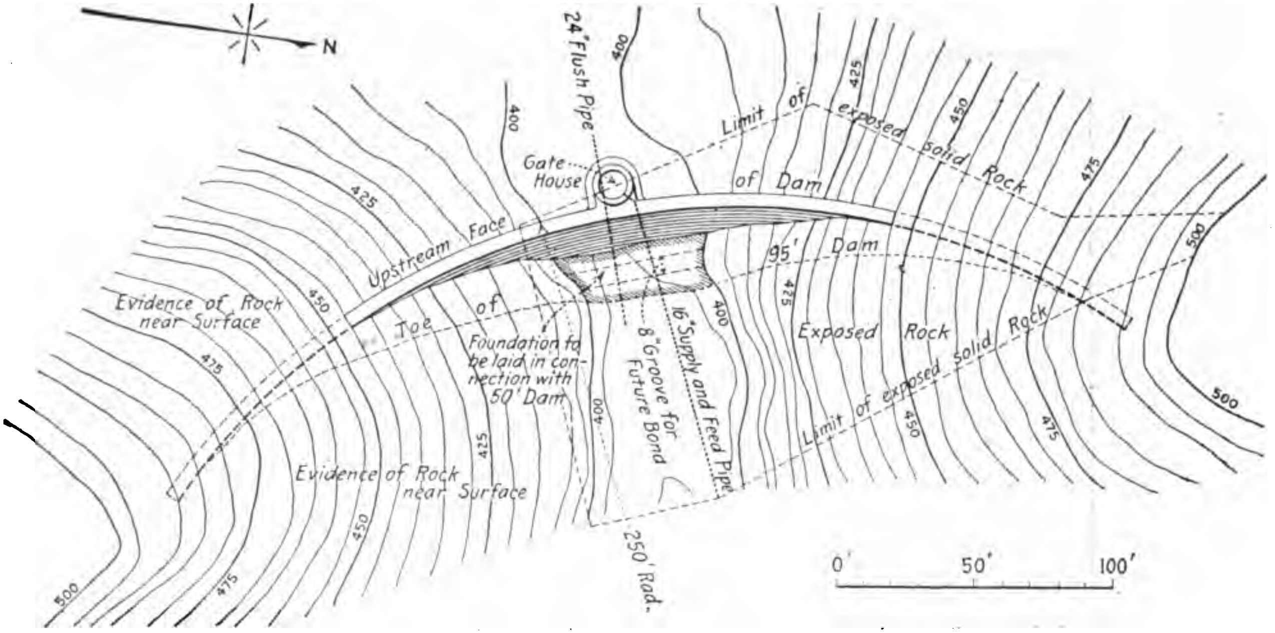
The outcrop of ledge on either side of the cañon, at the site selected for the dam, indicated that a very firm and solid foundation could be secured, as proved to be the case.

As a storage capacity of 60 000 000 gal. would serve the immediate needs of the water company and would probably be sufficient for a number of years to come, whereas ultimately a much larger storage would be required, it was desirable to decide upon a type of dam which could be built to such a height as to give this storage at the present time, with the provision that at some future time, the height of the dam could be increased sufficiently to give the additional amount of storage then required. A 50-ft. dam was sufficient to afford 68 000 000 gal. storage, while the site is such as to allow the construction of a dam 95 ft. in height, which would retain some 425 000 000 gal.

In order to provide for the ultimate increase in the height of the dam, it would have been necessary, had the Ambursen type been selected, to build the entire low level dam on the lines of the high level structure, whereas it was possible to design a solid concrete arched structure on lines suitable for the lower dam with the provision that ultimately this dam could be incorporated into and made part of a higher structure without increased present expenditure. Accordingly it was decided to construct a solid unreinforced concrete arched dam with a radius of 250 ft. and 50 ft. above the bed of the stream. See Figs. 14 and 15.

A comparison of the section of this dam with the sections of other similar structures appears in Table 5.

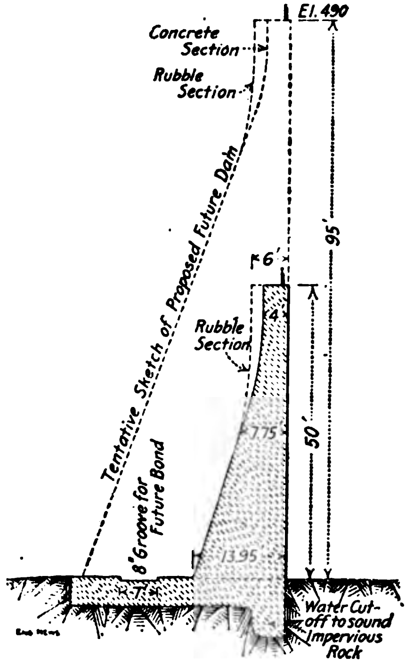
For further details upon the design of this structure reference


N
24" Flush Pipe
400
Gate House
Limit of exposed solid Rock
of Dam
Upstream Face
95' Dam
Toe of
Foundation to be laid in connection with 50' Dam
8" Groove for Future Bond
16" Supply and Feed Pipe
Exposed Rock
Limit of exposed solid Rock
Evidence of Rock near Surface
Evidence of Rock near Surface
250' Rad.
425
450
475
500
0'
50'
100'

PLAN OF THE ARCHED CONCRETE DAM FOR THE AGUA PURA CO., LAS VEGAS, N.M.

Fig. 14.

can be had to a paper by Charles W. Sherman, in *Engineering News* of October 27, 1910.


El. 490
Concrete Section
Rubble Section
Tentative Sketch of Proposed Future Dam
6'
4'
Rubble Section
7.75'
95'
50'
8" Groove for Future Bond
13.95'
7'
Water Cut-off to sound Impervious Rock

Section Through Crown of Present 50-Ft. and Proposed 95-Ft. Las Vegas Arched Dam.

FIG. 15.

CONSTRUCTION.

Contract for the construction of the dam was awarded on September 21, 1910, to Mauretz M. Sundt, a local contractor, carpenter, and builder, equipped with a plant sufficient for this undertaking, though his experience had been confined largely to the construction of buildings, foundations, and sidewalks.

TABLE 5.

PRINCIPAL DETAILS OF CURVED MASONRY DAMS.

Place.	Max. Ht. Ft.	Thick-ness Base.	Thick-ness Top.	Max. Stress in Arch. Lb. per Sq. In.	Rad. Up-stream Face.	Length Top.	Character of Rock.	Date.
(1) Katoomba, New South Wales	25	20.29	3.0	233	220	320	Sandstone	1905
(1) Picton, New South Wales	28	13.62	7.0	186	120	112	Sandstone	1897
(3) Winchester, Ky.	31	8.58*	4.83	498	318.4	407		
(1) Queen Charlotte Vale, New South Wales	32	8.65	3.0	155	90	113	Quartzite	1898
(1) Parkes, New South Wales	33.5	13.5	3.0	373	300	540	Granite	1897
(1) Lithgow No. 1, New South Wales	35	10.88	3.5	155	100	178	Sandstone	1896
(1) Wollongong, New South Wales	42	11.62	3.5	311	200	535	Basalt	
(1) Cootamundra, New South Wales	46	13.0	3.0	389	250	640	Granite	1898
(1) Wellington, New South Wales	48	10.0	3.0	311	150	350	Conglomerate	1899
(2) Bear Valley, Cal.	48 (Total 64)	8.4 at 48 ft.	3.17	825	335	300	Granite	
(1) Mudgee, New South Wales	50	18.0	3.0	311	253	498	Altered slate	1899
(1) Parramatta, New South Wales	52	15.0	4.8	223	160	225	Sandstone	
(3) Lewiston, Ida.	55.5	14.5	5.33	475	286.5	288		
(1) Tamworth, New South Wales	61	21.5	3.0	311	250	440	Granite	1898
(1) Medlow, New South Wales	65	8.96	3.5	186	60	124	Sandstone	1906
(1) Lithgow No. 2, New South Wales	87	24.0	3.0	155	100	221	Sandstone	1906
(2) Sweetwater, Cal.	90	46	12	188	222	380		
(4) Ithaca, N. Y.	90	7.75		283	67.85		Shale	1903
(2) Barossa, South Australia	95	34	4.5	242	200			1903
(2) Zola, France	119.7	41.82	19.02	196	158	205		
(4) Cheesman, Colo.	210 to 176 H. W.	72.66 at el. 100	18		399.89 at top		Granite	1900
(5) Pathfinder, Wyo.	210	94	10	181	(150 at center) (186.5 at base)			
Las Vegas (under contract)	50	15.50	5.0	350	250	210		1910
(proposed)	95	43.30	5.0	300	250	390	Sandstone	
(6) Cascadilla Creek dam, Ithaca, N. Y.	25	40	2.5	189	70	96	Shale	1904
(7) Upper Otay, Cal.	75	14	4	604	359	350		1900
(8) Crowley Creek, Malheur Co., Ore.	60	5.2	3.0	350	70	170		1898

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(1) *Eng. News*, May 19, 1910.
(2) Wegman's "Dams," 5th edition.
(3) Data obtained from Wm. Wheeler, engineer.
(4) Trans. Am. Soc. C. E., Vol. 53.
(5) JOUR. N. E. W. W. ASSOCIATION, June, 1906.
(6) *Eng. News*, November 10, 1910.
(7) Schuyler's "Reservoirs," 2d edition.
(8) *Eng. News*, August 24, 1911, p. 220.
* 15 ft. above base.

LABOR.

The labor employed upon the work was almost entirely Mexican, drawn from the immediate neighborhood, and was paid at the rate of $1.50 per day of ten hours.

EXCAVATION.

Work was begun, September 28, 1910, by stripping the earth from practically the entire site of the dam. The earth was thrown out upon the downstream side of the excavation, and the rock on the upstream side and rolled down the hill to the valley, where it was picked up and hauled to the crusher. About one fourth of the entire excavation (or, more particularly, 245 cu. yd.) was classified as earth excavation and was paid for at the contract price of 80 cents per cu. yd.

The rock excavation consisted of a fine, close-grained quartzite, lying below the surface at depths varying from a few inches to 6 ft., as shown in the accompanying photograph, Plate XVI, which also shows the ledge inclined or dipping to the west, or toward the reservoir, with an inclination of about 60 degrees with the horizontal.

In order to avoid the excavation of the ledge below the dam within the bed of the stream when it may prove desirable to raise the dam to a higher level, the ledge found in the river bed was excavated to an average depth of 6 ft. for the entire width necessary for the ultimate 95-ft. dam, said excavation being carried well into the side walls of the cañon and filled with concrete as shown in Plate XVI.

CONCRETE.

The concrete plant consisted of a Chicago Improved Cube Mixer, of ½-cu. yd. capacity. The stone was crushed at the site of the work by means of a small portable crusher.

ARRANGEMENT OF PLANT.

At the beginning of the work, in order to utilize the rock which was excavated from the site of the dam, the crusher was located about 100 ft. west of the face of the dam, within the reservoir site,

PLATE XVI.
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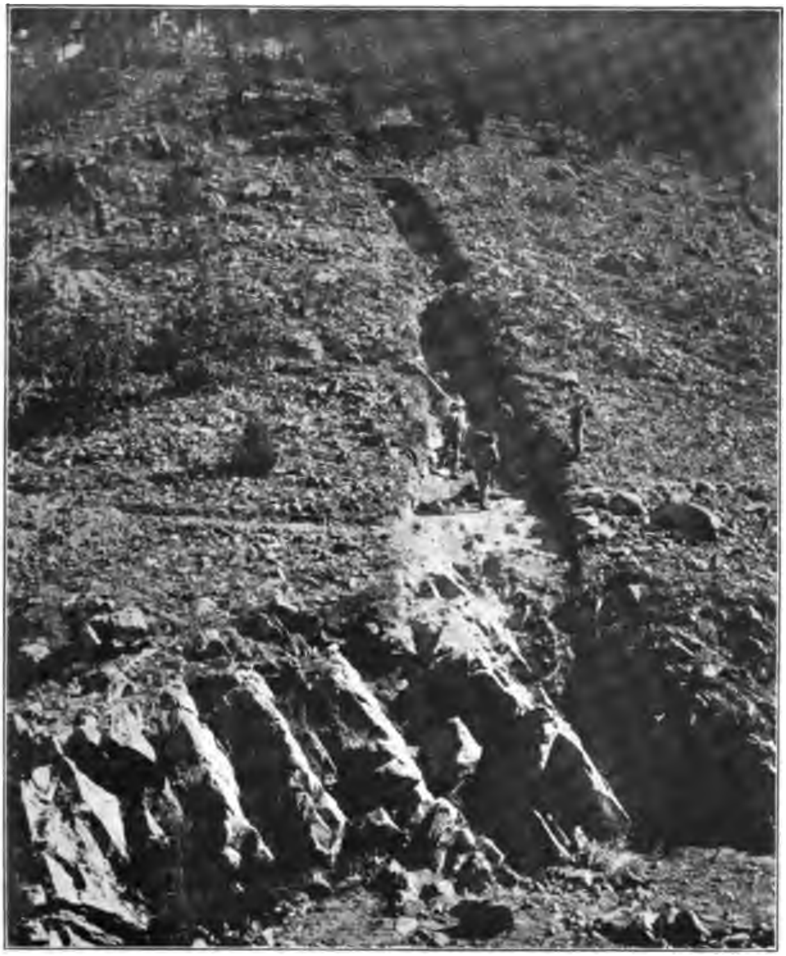
BARNES ON
LAS VEGAS DAM.



EXCAVATION FOR FOUNDATIONS AT SOUTHEASTERLY END OF DAM.

U of M

while the mixer was placed between the crusher and the site of the dam, the crushed stone being piled in close proximity to the mixer.

This location proved to be extremely convenient for the first three weeks, or until a height was reached that made the incline of the runway too steep for the wheelbarrows.

CRUSHED STONE.

In order to provide sufficient stone for the crusher, a quarry was selected within the reservoir basin, on the south side of the cañon and about 100 ft. westerly of the site of the dam. When the stone from the excavation was exhausted, the crusher was moved back, and the rock, as excavated from the quarry, was rolled down the hill, broken by means of large hammers, and fed to the crusher in its new location. At the same time (December 6) the mixing plant was also moved further from the dam, this position being adopted in order to make possible the erection of a runway for the wheelbarrows which would be sufficiently flat to permit of easy wheeling, even after the dam was well advanced.

By December 30, after three weeks' service in the second location, the runway again became too steep, and it became necessary to select a third location for the mixing plant.

As the quarry selected had developed a very inferior grade of stone, and as good material was difficult of access, the contractor decided, at the engineer's suggestion, to locate his plant on the opposite side of the valley, on top of the hill in line with the dam and near the newly constructed roadway over which it was necessary for all the sand to be carted.

By adopting this location, it was possible to save the expense of wheeling partly filled wheelbarrows of concrete up a long and tedious incline, and the operations of crushing and mixing were reduced to a minimum of labor and of effort. The expense of hauling the sand completely over the hill and down into the valley was also partly eliminated, as the teams could, in this new location, dump their load on top of the hill, thus making nearly twice as many trips as was possible in the second location.

Accordingly, the plant was moved during the first week in January to its third position, on the top of the hill, as shown in

Plate XVII. A terrace was constructed on the side of the hill, on which the mixing platform was built, of such a size and at such an elevation below the level of the roadway in which the crusher was placed as to provide ample storage for fully a day's supply of crushed stone. The mixer was located at a lower level so that the mixing platform was level with the top of the feeding hopper. The quarry was established on the top of the hill, where there was found an ample supply of very satisfactory stone. As the stone thus quarried was within easy reach of the crusher, the handling of materials was reduced to a minimum from the time the stone was quarried until it was dumped from the mixer directly into a long chute which led directly from the mixer to a distributing box just above the wheeling platform constructed on the top of the forms.

The loading of concrete into wheelbarrows was controlled by a shear gate in this distributing box by means of which each batch of concrete was disposed of as rapidly as it was mixed, while separate runways for the loaded and empty wheelbarrows made it possible to distribute the concrete with a minimum of labor.

By this arrangement about twice as much concrete was mixed and placed per day as the same force of men had been able to do during the latter part of the time when the mixing plant was in its second position.

RELATIVE OUTPUT DURING DIFFERENT PERIODS.

In order to determine the relative amounts of labor employed in the several subdivisions of the work during each of the three periods of construction, a mass diagram has been prepared, as shown in Fig. 16. The three periods above referred to are determined by the location of the plant, namely, first period, with mixing machinery near the site of the dam; second, with machinery, including the crusher, in the valley at some distance from the dam, and third, with entire outfit on top of the hill in line with the dam.

The mass diagram was constructed with accumulated volumes of concrete in cubic yards, as abscissæ, and the accumulated amount of labor expended, as ordinates. The records of labor

PLATE XVII.
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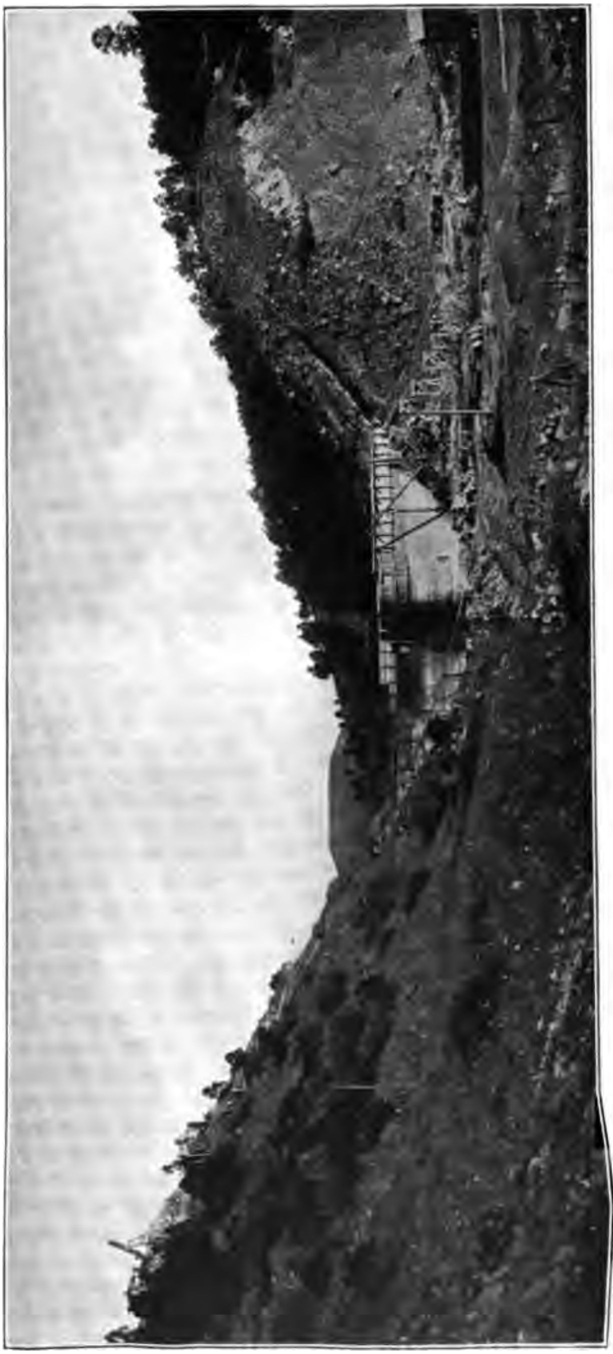
LAS VEGAS DAM.



VIEW OF PARTLY COMPLETED DAM FROM RESERVOIR SITE.

employed in the following subdivisions of the work, namely, quarrying, crushing stone, concrete mixing and placing, and stagings and forms, have been plotted in terms of the corresponding amounts of concrete placed. These points have been connected, forming an irregular line, while the average condition for each period, for each subdivision of work, has been shown by a straight line of heavy weight. These data are expressed in tabular form, Table 6.

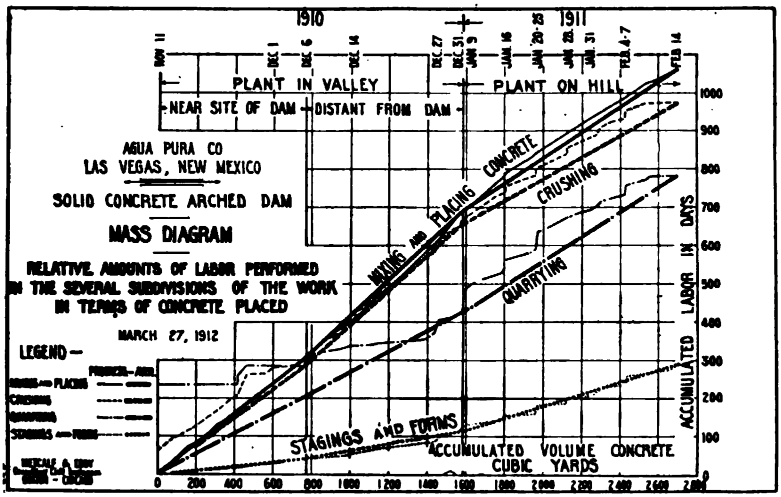


FIG. 16.

QUARRYING.

The quarry was well advanced when concreting began, 230 days of labor having been performed, while all of the stone quarried was consumed by December 31, at which time 1 582 cu. yd. of concrete had been placed, with a total expenditure of 424 days of labor in quarrying. The amount of concrete laid per laborer employed in the quarry is indicated by the slope of the line drawn from the origin to the point whose coördinates are 1 582; 424. In other words, 3.73 cu. yd. of concrete were laid during this period per day's labor employed in the quarry. Similarly, we find that

3.14 cu. yd. of concrete were laid after January 1 for each day of labor employed in the new quarry upon the top of the hill.

STONE CRUSHING.

In the same manner we find that during the first period of construction 2.60 cu. yd. of concrete were laid for each day of labor employed in crushing stone, whereas during the second period only 2.28 cu. yd. of concrete were laid per day of labor, while during the third period, 3.5 cu. yd. of concrete were laid per day of labor in crushing stone.

TABLE 6.

CONSTRUCTION OF ARCHED CONCRETE DAM FOR THE AGUA PURA COMPANY AT LAS VEGAS, N. M. 1910–1911.

Yardage of Concrete placed per Laborer-day expended in the Several Subdivisions of the Work during the Three Periods of Construction, determined by the Relative Positions of the Mixing and Crushing Plants to the Dam.

Subdivision of Work.	First Period.	Second Period.	Third Period.
	Machines in the Valley.		Machines on Top of Hill in Line with Dam.
	Near Dam.	150′ from Dam.	
Quarry	3.73		3.14
Crusher	2.60	2.28	3.50
Concrete mixing and placing	2.52	2.10	3.02
Stagings and forms	20.8	11.0	6.33

CONCRETE MIXING AND PLACING.

Similarly, during the first period 2.52 cu. yd. of concrete were laid for each day of labor employed in mixing and placing, while during the second period only 2.10 cu. yd. were laid, and during the third period 3.02 cu. yd. were laid per day of labor employed in mixing and placing.

STAGINGS AND FORMS.

In connection with the construction of stagings and forms, we find that for each day's labor employed during the first period 20.8 cu. yd. were laid, while during the second period but 11.0

cu. yd. were laid, and that during the third period, only 6.33 cu. yd. were laid for each day of labor employed in building stagings and forms.

QUARRY. — RATE OF PROGRESS.

That the quarrying cost more during the third period than during the first two periods is undoubtedly due to the fact that the carpenters were unable to provide forms during the third period sufficient to furnish the mixing and placing crew with a full day's employment. Consequently, almost every day the labor from this crew were turned into the quarry, which resulted in disorganizing the regular quarry crew, so that the increase in output was not proportionate to the increase in labor employed. Had it not been for this disorganizing effect, or had good foremanship been maintained in the quarry, it is probable that the quarrying during the third period would have been at about the same rate as during the first two periods, or possibly slightly better.

CRUSHED STONE. — RATE OF PROGRESS.

That more yardage were placed per laborer employed in crushing during the first period than during the second, is due to the use of the rock found in the excavation for the dam, which was readily delivered to the crusher. The position of the crushed stone platform in the third period, some ten feet lower than the base of the crushing plant, thus avoiding the congestion of the crushed stone around the crusher, together with the fact that the stone was utilized about as fast as it was crushed, as well as the fact that the raw material was piled conveniently close to the crusher, is sufficient reason to explain the great difference in results during the third period.

CONCRETE. — RATE OF PROGRESS.

The slopes of the lines on the diagram, Fig. 16, representing the mixing and placing of concrete, vary in the different periods about as might be expected, except that during the first period, with the machinery placed at the edge of the excavation and some distance above the bottom thereof, the concrete should have been made and placed under such conditions with far less labor than would be required after the machinery was moved some 150 ft. from the edge of the excavation in a position which required not only longer wheeling circuits but during most of the time the wheeling of loaded wheelbarrows upgrade, whereas in the first position the bulk of the loads were wheeled downgrade and upon very short circuits.

It is probable that the difference is due to the fact that during this first period a great deal of time was lost on account of leaking flues in the old boiler which supplied the steam for the concrete mixer, thus resulting in the entire crew remaining idle while the engineer cleaned, or rolled, his flues. It is estimated that had the new boiler, which was used during the second period, been made use of from the beginning of the work, the concrete might have been placed during the first period at the rate of 3.5 yd. per day of labor employed.

Although the curve showing the actual conditions during the second period as plotted is not far different from the straight lines showing the average conditions, it is to be noticed that the slope of the line showing actual conditions at the end of the second period is much steeper than the average, and it is believed that had the work continued for another week with the machinery in the second position, the slope would have represented the placing of not more than one yard of concrete per day of labor employed, whereas by moving to the top of the hill it was possible to mix at the rate of three yards per day of labor employed.

The reasons for this improvement have already been alluded to, and may be enumerated as follows: First, the relation of the operating platform, mixer, chutes, and wheeling platform were such as to enable each set of men to perform their respective tasks without interference, and with a minimum of labor. Second, with the operating platform located above the mixing hopper the engine was no longer called upon to raise the "feeding pan" in order to charge the mixer, thus saving both time and steam, as the hopper, which was loaded while the previous batch was being mixed, could be discharged directly into the mixer immediately following the dumping of the previous mix. Third, the wheelbarrow crew could remove and place the concrete as fast as it was mixed, and there was always an ample supply of crushed stone and sand in close proximity to the mixing hopper, and the water was rapidly supplied through a large valve from a barrel supported over the mixer, so that the whole operation was one that created interest among the workers to the extent that each appeared to desire to have his part of the process ready without causing delay to the operation.

The average output during this third period was at the rate of 36 one-bag, or 0.2 cu. yd., batches per hour, while the maximum day's output was at the rate of 47 batches per hour, which rate was continued for seven hours, and the minimum rate was 26 batches per hour.

FORMS.

It is to be noticed that although there was practically no carpenter work during the first half of the first period, except for the construction of runways, there was nearly as much labor employed per yard of concrete during the first part of this period as was employed during the later portion. This is due in great measure to the same cause as has already been referred to in connection with the making of concrete, namely, an insufficient and worn-out boiler gave the crew frequent opportunities to remain idle.

That more labor was required during the third period than during the second is due to the fact that all of the concrete was delivered to the wheeling crew at the bottom of the incline chute at the north end of the dam, and as the wheeling platforms were supported upon the top of the forms it was impossible to construct new forms at the north end of the dam while the concrete was being delivered to the dam. Accordingly, the concrete mixing was stopped for a day while the carpenters erected the forms at the north end of the dam. While this section was being filled the carpenters then prepared the adjoining section of forms, and while this was being filled they erected the third set of forms, and similarly with the fourth section, so that the fifth day the mixing crew was laid off and the carpenters rushed upon the erection of the northerly set of forms for the next zone, erecting this in one day, in order not to delay the mixing more than one day.

The result was that a large number of inexperienced men were assigned to assist the carpenter in the construction of these forms, and especially so on the day while the mixer was shut down, as shown by the vertical lines in the diagram which gives a " saw-tooth " effect to the line representing the actual conditions. It is to be noted that were it not for the influx of labor on these special days the " saw-tooth " effect would have been less marked and the slope of this line would have been substantially parallel to the slope of the average line during the second period, thus indicating that the excess cost of stagings and forms during the third period was due in great measure to the superabundance of labor on the days mentioned.

UNIT COSTS.

Daily cost accounts were kept by the engineer, under the headings of " Excavation " and " Concrete," the latter being subdivided as follows: Quarry, Crushed Stone, Sand, Cement, Mixing, Heating, Wheeling, Placing, Placing Cyclopean Masonry, Water Supply, and Stagings and Forms.

For each of the foregoing subdivisions, separate records were kept under the following headings: " Labor and Teams," " Superintendent, Foreman, and Blacksmith," " Materials and Supplies," and " Tools, Equipment, and Repairs."

In order to make the records as complete and accurate as possible, arrangements were made with the contractor whereby he gave the engineer access to his time-book and furnished monthly statements of amounts and costs of materials furnished and of expense involved in repairs, etc., the items of which were distributed according to the engineer's discretion.

It is believed that the tabulated costs submitted herewith in Tables 7 and 8 represent very closely the actual unit costs upon this work. In Table 9, a summarized statement of costs has been prepared, showing the relation of " cost to the contractor " to the " cost to the Agua Pura Company," indicating the probable profit and loss under the items of earth and rock excavation, concrete, and under the item of extra work. As will be noted from the memorandum attached to this table, these figures include $1 224 extra compensation paid to the contractor for prosecuting the work through the cold weather instead of closing down as the contract permitted him to do.

PLATE XVIII.
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LAS VEGAS DAM.

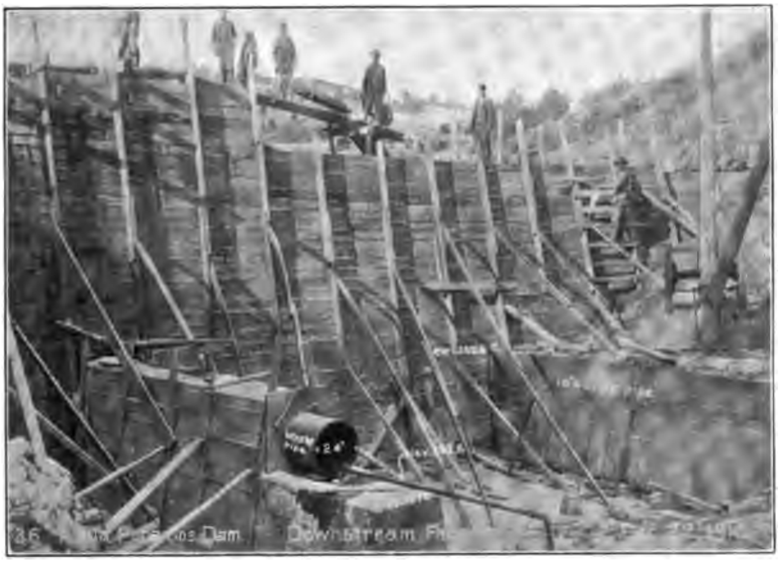

FIG. 1.
DAM UNDER CONSTRUCTION — DOWNSTREAM FACE.

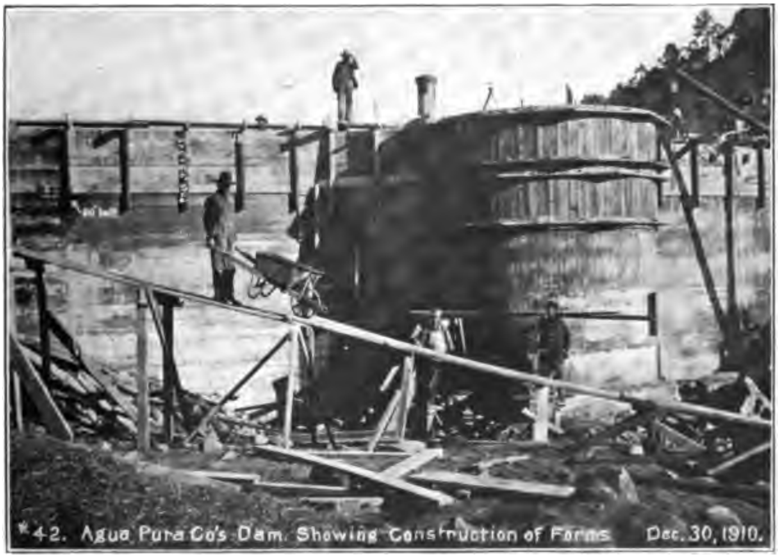
*42. Agua Pura Co's Dam. Showing Construction of Forms Dec. 30, 1910.

FIG. 2.
UPSTREAM FACE OF DAM DURING CONSTRUCTION.

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TABLE 7.

Agua Pura Company's Dam.

ESTIMATED COST TO CONTRACTOR, FROM BEGINNING TO DECEMBER 31, 1910. (PLANT IN VALLEY.)

Concrete (1 582 cu. yd.).

Item.	Labor and Teams.		Supt., Foreman, and Blacksmith.		Materials and Supplies.		Tools, Equip., and Repairs.		Total Cost.	
	Total. $	Unit $	Total. $	Unit $	Total. $	Unit $	Total. $	Unit $	Total. $	Unit $
Quarry										
Drilling..	167.85	0.10								
Labor...	394.78	0.25								
Total..	562.63	0.35	89.57	.06	77.88	.05	13.86	.01	743.94	0.47
Crushing										
Setting up	39.25	.02								
Engineer.	198.20	.13								
Labor and team...	847.65	.54								
Total..	1 085.10	.69	103.20	.07	120.95	.07	439.24	.28	1 699.19	1.11
Sand										
Teams...	306.40	.19								
Labor....	149.60	.10								
Total..	456.00	.29	42.60	.03	3.80		17.11	.01	519.51	0.33
Concrete										
Mixing...	36.00	.02								
Teaming coal...	6.00									
Engineer.	123.45	.08								
Sand.....	101.20	.07								
Stone....	202.40	.13								
Cement..	50.60	.03								
Water & dump..	101.10	.07								
Total.	620.75	.40	56.60	.03	92.30	.06	366.72	.23	1 136.37	0.72
Heating Material.	82.35	.05	8.15		85.05	.06	3.00		178.55	0.11
Wheeling...	351.60	.22	35.10	.02			21.00	.02	407.70	0.26
Placing....	155.85	.10	15.65	.01	31.40	.02	12.60	.01	215.50	0.14
Placing Cyclop....	55.85	.04	5.60				50.50	.03	111.95	0.07
Stage and Forms										
Carpenter	106.50	.06								
Labor....	126.95	.08								
Team....	62.30	.04								
Total..	295.75	.18	22.10	.02	385.10	.24			702.95	0.44
Cement										
Cement shed...	79.80	.05								
Teams...	192.00	.12								
Total..	271.80	0.17	21.30	.02	5 113.00	3.24	82.50	.05	5 505.60	3.48
Total concrete....	3 937.68	2.49	399.87	.26	5 926.48	3.78	1 006.53	.64	11 270.56	7.13

TABLE 8.

AGUA PURA COMPANY'S DAM.

ESTIMATED COST TO CONTRACTOR FOR MONTHS OF JANUARY AND FEBRUARY (TO MARCH 15, 1911). (PLANT ON HILL.)

Concrete (1 121 cu. yd.).

Item.	Labor and Teams.		Supt., Foreman, and Blacksmith.		Materials and Supplies.		Tools, Equip., and Repairs.		Total Cost.	
	Total. $	Unit $	Total. $	Unit $	Total. $	Unit $	Total. $	Unit $	Total. $	Unit $
Quarry										
Foreman.	56.00	0.05								
Labor....	497.55	.45								
Team....	36.80	.03								
Total..	590.35	0.53	84.41	.07	18.30	.02	11.20	.01	704.26	.63
Crushing										
Setting up	32.50	.03								
Engineer.	134.50	.12								
Labor....	408.70	.36								
Total..	575.70	.51	72.33	.07	60.40	.05	148.02	.14	856.45	.77
Sand										
Teams...	314.00	.28								
Labor....	128.85	.11								
Total..	442.85	.39	52.56	.05	31.25	.03	13.06	.01	539.72	.48
Cement										
Cement shed...							44.26			
Labor...	9.00	.01								
Teams...	77.20	.07					4.50			
Total..	86.20	.08	11.80	.01	3 711.53	3.31	48.76	.04	3 858.29	3.44
Concrete Mixing										
Setting up	38.75	.03								
Engineer.	75.50	.07								
Sand.....	37.30	.03								
Stone....	115.65	.11								
Cement..	38.80	.03								
Water and dump...	93.90	.09								
Total..	399.90	.36	49.72	.04	68.44	.06	199.62	.18	717.68	.64
Heating Material.	8.25	.01	1.14				6.00		15.39	.01
Wheeling...	148.35	.13	20.14	.02			14.00	.01	182.49	.16
Placing....	78.90	.07	10.65	.01			24.00	.02	113.55	.10
Water Supply......	82.65	.07	11.42	.01			11.50	.01	105.57	.09
Stage and Forms										
Carpenter	164.75	.15								
Labor....	227.77	.20								
Total..	392.52	.35	53.28	.05	238.54	.21			684.34	.61
Cleaning up	220.55	.20	12.95	.01					233.50	.21
Total concrete	3 026.22	2.70	380.40	.34	4 128.46	3.68	476.16	.42	8 013.34	7.14

PLATE XIX.
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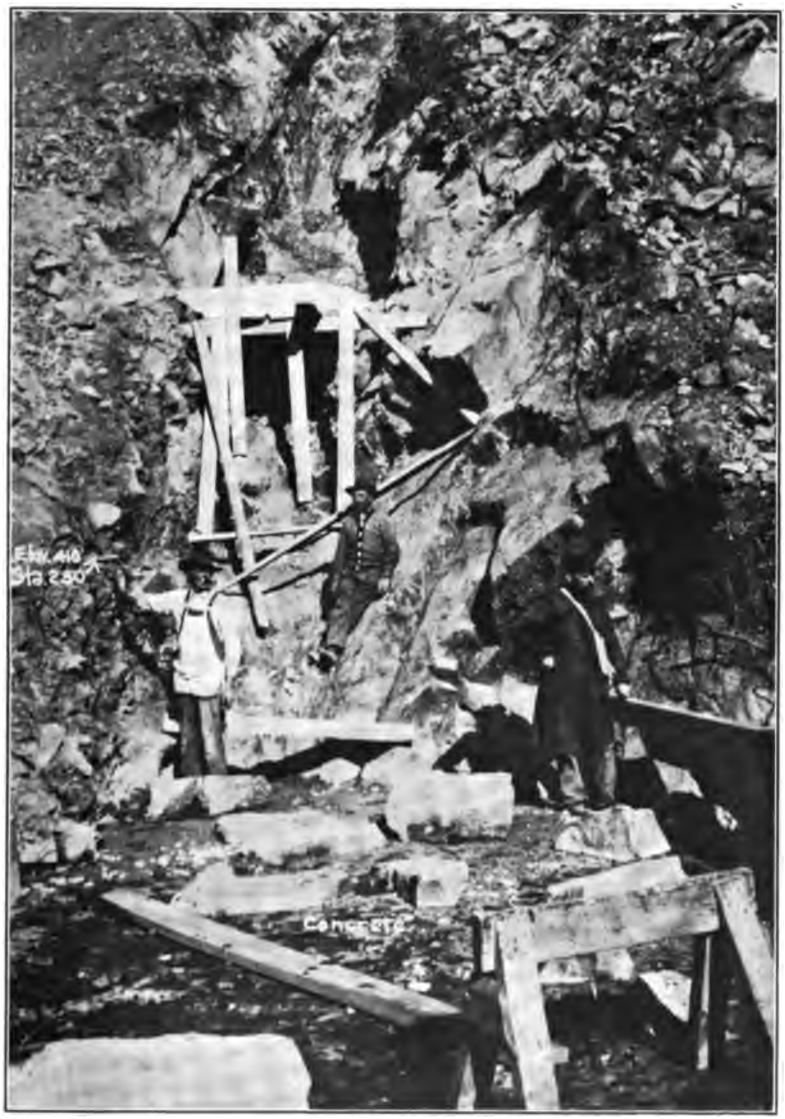
LAS VEGAS DAM.



FOUNDATION OF DAM.

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TABLE 9.

CONCRETE MASONRY DAM BUILT FOR THE AGUA PURA COMPANY, LAS VEGAS, N. M., 1910, 1911.

SUMMARIZED STATEMENT COMPARING COST TO THE CONTRACTOR WITH THE PRICE PAID BY THE WATER COMPANY.

Item.	Cubic Yards.	Cost to Contractor.		Cost to Agua Pura Co.		Contractors' Profit and Loss.			
						Profit.		Loss.	
		Total.	Unit.	Total.	Unit.	Total.	Unit.	Total.	Unit.
Earth excavation	245	$1 533.15	$1.50	$1 460.00	$1.43			$73.15	$0.07
Rock excavation	790								
Concrete in dam, gatehouse substructure and superstructure	2 720*	19 283.90	7.09	21 318.05†	7.86	$2 034.15	$0.77		
Premium on indemnity policy		246.86						246.86	
Extra work		225.98		259.88		33.90			
		$21 289.89		$23 037.93		$2 068.05 $1 748.04		$320.01	

* 17 cu. yd. has been added to yardage paid for in final estimate to include yardage contained in gatehouse superstructure.

† Includes $1 224.00 extra compensation paid for prosecuting work through cold weather.

Wages: Mexican labor, 15c.; sub-foreman, 17½c.; engineer, 25c.; carpenter, 30c. and 20c.; foreman, 35c.; double teams, 40c.

Materials: *Cement*, $3.02 f. o. b. Hot Springs; rebate on bags, 30c. — figured as 25c. to allow for loss.
Lumber (per M ft. b. m. at mill), $17.00; mill work, $0.60. Cull lumber, $10.00.
Stone, sandstone quarried and crushed at site of work.
Sand, river sand screened and hauled about one-half mile.
Coal, $3.00 per net ton (f. o. b. Hot Springs).

Contractor's Compensation. The above figures of "Cost to Contractors" include an allowance of $400 or $8.00 per day for fifty days' time spent by him at the site of the work.

The hourly rates of wages paid are as shown in the footnote, namely, — Mexican labor, 15¢; subforemen, 17½¢; engineer, 25¢; carpenter, 30¢ and 20¢; foreman, 35¢; and double teams, 40¢.

The average cost of materials was as follows: Cement, $3.02, f. o. b. Hot Springs, with rebate on bags amounting to 30¢, which has been figured in these costs at 25¢ to allow for loss, giving net cost of cement $2.77. Lumber, $17.00 per M ft. b. m.; cull lumber, $10.00 per M ft. b. m. at the mill. Mill work, 60¢ per M ft. Stone was quartzite quarried at the site of the work. Sand was secured from the river bed, screened and hauled about 0.5 mile. Coal, bituminous, $3.00 per net ton, f. o. b. Hot Springs.

In figuring the costs, an allowance was made for actual time spent by the contractor upon the work at the rate of $8.00 per day, and included fifty days' time, amounting to $400.

In Table 10 is given a statement of the charges included in the force account, which table indicates the first cost of the machinery, tools and materials, the amount charged to the work and its percentage of the first cost and the estimated value of the several items at the close of the work. From this table it will be seen that an allowance for tools and equipment, amounting to $1 066.20, has been included, which, compared to the first cost of the tools and equipment, amounting to $2 904.90, is equivalent to nearly 37 per cent. of the first cost.

MATERIALS. — CEMENT.

The cement used upon this work was the " El Toro " brand, manufactured by the Southwestern Portland Cement Company at El Paso, Tex., and proved to be a most satisfactory cement. Tests were made in accordance with the specifications of the American Society of Civil Engineers by the George Pierce Testing Laboratory at Portland, Colo., and the cement was purchased a sufficiently long time in advance to enable the securing of a 28-day test.

SAND.

The sand was secured from the bed of the Gallinas River, passed through a ½-in. screen in order to remove occasional gravel, and hauled fully 0.5 mile up two long and steep hills.

PLATE XX.
N. E. W. W. ASSOCIATION.
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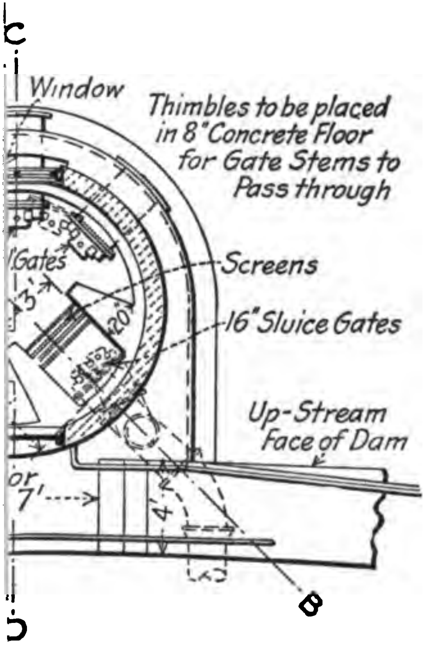
BARNES ON
LAS VEGAS DAM.


C
Window
Thimbles to be placed in 8" Concrete Floor for Gate Stems to Pass through
Gates
Screens
3'
20'
16" Sluice Gates
Up-Stream Face of Dam
7'
4'
B

Gate Chamber,
oved.)

SECTION THROUGH
AS VEGAS ARCHED DAM.

CRUSHED STONE.

As already described, the stone was of good quality sandstone, and was crushed locally. In order to supply the stone in sufficient quantity to keep the mixing and placing crews busy throughout the day it was necessary to operate the crushing plant in two shifts of ten and twelve hours respectively.

TABLE 10.

STATEMENT OF CHARGES INCLUDED IN FORCE ACCOUNT.

Tools and Equipment.	First Cost.	Amount Charged.	Per Cent. Charged.	Value Remaining.
Cement mixer	$700.00	$350.00	50	$350.00
Stone crusher	1 350.00	337.50	25	1 012.50
Steam pump	57.50	11.50	20	46.00
Boiler	114.70	28.70	25	86.00
Boiler hoods	6.25	1.50	24	4.75
Derricks and ropes	201.08	100.50	50	100.58
Wheelbarrows and small tools	155.62	116.83	75	38.79
Blacksmith tools	30.96	10.06	33	20.90
Wagon — new	85.00	22.10	26	62.90
Sand screens	38.30	16.97	44	21.33
Torches	4.25	2.54	60	1.71
Flue roll and beader	4.00	.80	20	3.20
Steam and water hose	52.00	31.20	60	20.80
Pliers and wrenches	2.02	.60	30	1.42
Old smoke-stack	10.00	9.00	90	1.00
Pipe and fittings	26.97	10.80	40	16.17
Injector	6.75	2.70	40	4.05
Belting (not used)	21.50	1.50	7	20.00
Wagon sheets	38.00	11.40	30	26.60
Totals	$2 904.90	$1 066.20	36.7	$1 838.70
Cement Shed				
Material	145.06	95.06	65	50.00
Labor	25.20	25.20	100	
Repairs	417.23	367.23		50.00*
Totals	$3 492.39	$1 553.69		$1 938.70
Materials				
Cement remaining				120.00
Cement bags returned				785.00
Lumber — cull				50.00
				$2 893.70

* Rebate on pitman.

FORMS.

The forms were made of 2-in. by 8-in. planks, dressed on two edges and one face, and for the lower twenty feet of the structure were braced by means of 2-in. by 6-in. studdings, with numerous 2-in. by 4-in. braces, as shown in Plate XVIII, Fig. 1. For the balance of the structure the forms were made by the use of 3-in. by 5-in. studs, 6 ft. long, with bolt holes placed 4 ft. apart 6 in. from lower end and 18 in. from upper end, so arranged that the $\frac{5}{8}$-in. bolts, 20 in. long, previously set in the wet concrete 12 in. below the surface of the concrete and projecting 8 in. from the face of the dam, would pass through the lower hole of these studdings, which would then be bolted up against a 2-in. wooden

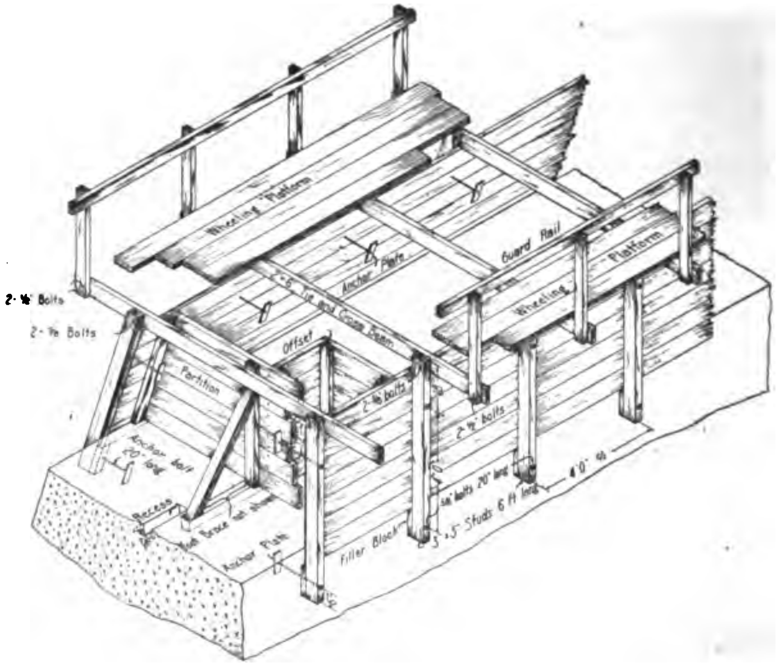


FIG. 17.
FORMS FOR CONCRETE DAM.

PLATE XXI.
N. E. W. W. ASSOCIATION.
VOL. XXVI.
BARNES ON
LAS VEGAS DAM.

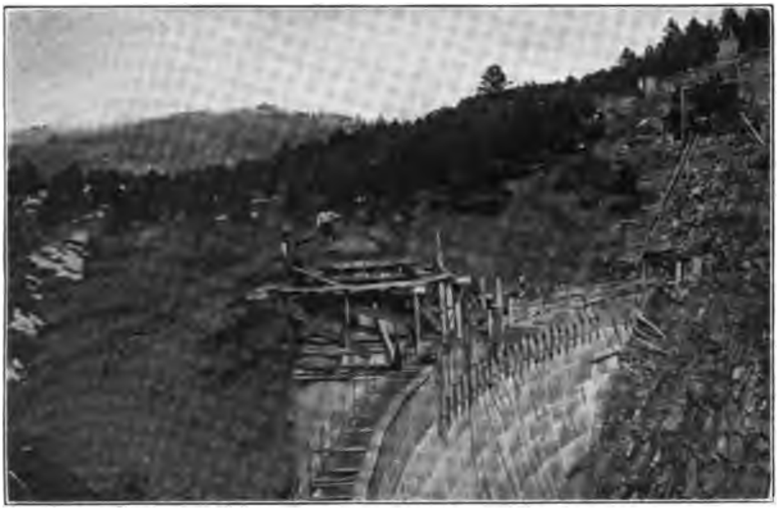


FIG. 1.
TOP OF COMPLETED DAM BEFORE REMOVAL OF FORMS.

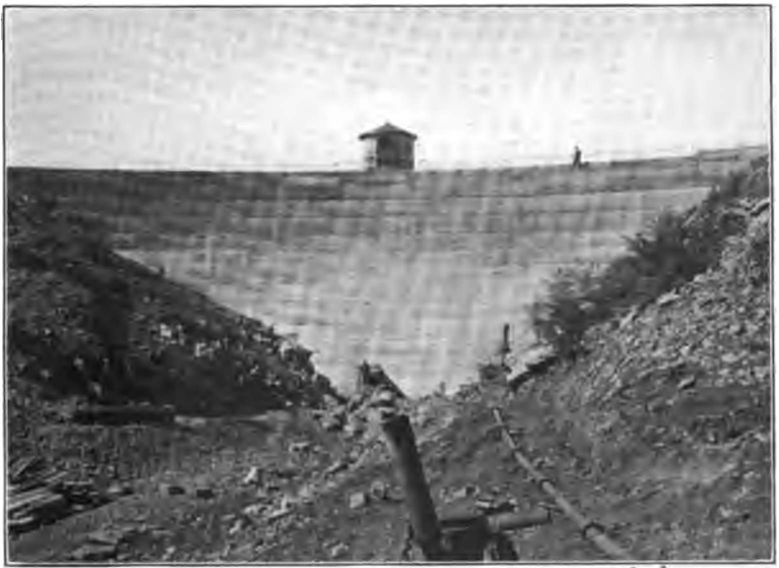


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FIG. 2.
DOWNSTREAM FACE OF COMPLETED DAM.

washer which separated the studding from the face of the concrete by the thickness of the forms.

As these studdings were arranged in pairs on either face of the dam on radial lines, it was possible to hold the forms rigidly in place by means of tie-braces across the top, which braces also served to carry the wheeling platforms across the top of the dam, as shown in Plate XVIII, Fig. 2, and Fig. 17. Each time a new block of concrete was placed, new bolts were inserted in the upper holes bored through these studdings, which in turn served as anchorages for the next tier of concrete.

No difficulty was experienced in keeping the forms in line except when the last layer of concrete was placed; in order to bring the dam to the finished crest in one zone, rather than to permit two thin zones to be constructed at the top of the dam where the pressure of ice action must be guarded against, it became necessary to splice these studdings.

HEATING MATERIALS.

As the thermometer in these cañons, during the winter months, frequently drops below freezing during the night and early morning, and sometimes even considerably below zero, whereas during the middle of the day the thermometer is almost always above freezing and frequently remains in the vicinity of 55 degrees and 60 degrees for a greater portion of the day, it was deemed advisable to be prepared to heat the sand and water so that the concrete might be thoroughly warmed when placed. Accordingly, a number of large condemned iron smoke stacks were procured, in which cord wood could be burned while the sand was piled over and around them, by which means it was possible to secure thorough and complete heating. The water was warmed by means of a steam jet constantly blowing into the water tank, and the concrete was covered with canvas, straw, and boards during the night.

We were, however, fortunate enough to experience but little weather in which the temperature was so low as to require the heating of the sand, except on four or five occasions, although it is true there were two periods of several days' duration when the thermometer went as low as 10 degrees to 20 degrees below zero, but on each of these occasions the work was shut down at the time on account of mechanical defects in the machinery or for other causes.

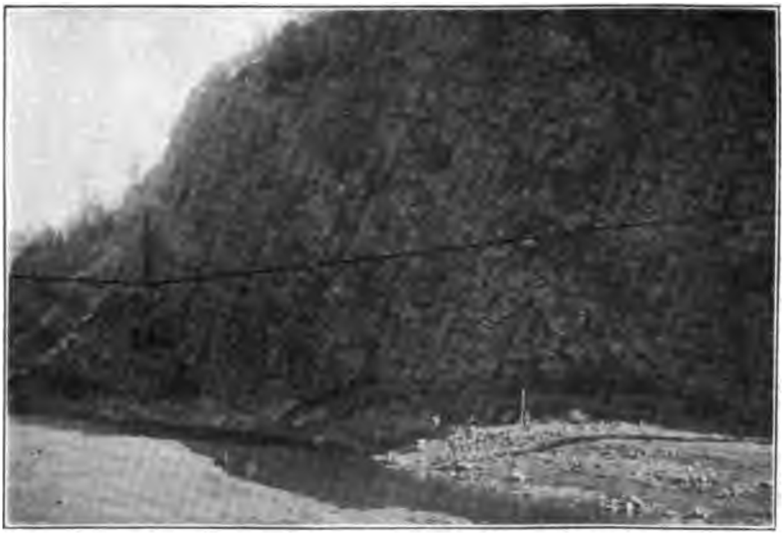
CYCLOPEAN MASONRY.

When the work was contracted it was expected that the Cyclopean form of masonry would be adopted, and with this in view, the contractor erected two small guy derricks, hand operated, which proved to be entirely inadequate for handling the large stones profitably and satisfactorily, with the result that probably not over 200 cu. yd. of stone were thus utilized, and this only in the lower portion of the structure. It is probable that not over 20 per cent. of the first thousand yards of concrete was composed of large stones, or not over 8 per cent. of the entire structure.

When the cyclopean method was used, the stones were placed to break joints horizontally and projecting above the top of the concrete at the end of the day's work, so as to form dentals by which the next course of concrete would be bonded thereto, as shown in Plate XIX. After the cyclopean form was discontinued, the bonding in the horizontal surfaces was secured by imbedding 4-in. by 4-in. timbers, beveled ½ in. on each of the two opposite surfaces, placed lengthwise of the dam in the middle of the surface, which were removed when the surface was cleaned preparatory to the construction of the next course. The vertical joints within a given course were made by means of a three-faced bulkhead, thus securing an offset of about 2 ft. about midway of this joint.

Before the concrete was placed in the excavation the surfaces of all ledge were thoroughly cleaned of earth, dust, and vegetable matter by means of a stream of water from a hose under pressure, or else by means of steam under high pressure, together with stiff brooms and shovels. In a similar way the surfaces of concrete were cleaned before the succeeding layer of concrete was placed, thus insuring not only the removal of dust, dirt, and chips, but also securing the thawing of any ice which occasionally was found on the surface of the concrete in early morning.

Plate XXII.
N. E. W. W. ASSOCIATION.
VOL. XXVI.
BARNES ON
LAS VEGAS DAM.



Cliffs along Gallinas River, and Line of Proposed Flume.

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GATE CHAMBER.

The gate chamber was built on the upstream face of the dam, and contained two gates at different levels on supply main, and three gates leading into the reservoir at different levels so as to provide for circulation in the waters of the reservoir. These gates, together with a blow-off gate, were operated from the gate-house floor by means of bevel-geared gate-stands anchored thereto. Provision was also made within the gate-house for two sets of screens for each of the inlet gates, although at the present time but one screen was placed for each gate. The openings for the 24-in. gates leading into the reservoir were protected by means of gratings so as to prevent floating material from flowing into the gate-chamber. See Plate XX.

COMPLETION OF THE DAM.

With the exception of the construction of the gate-house, the dam was completed February 14, 1911. It contains 2 703 cu. yd. of concrete. The excavation for foundations amounted to 790 cu. yd. of rock and 245 cu. yd. of earth. See Plate XXI.

GATE-HOUSE.

The superstructure of the gate-house was built with a small crew of men in three days after the forms were erected. The construction of these forms required the services of one carpenter and five men for a period of three days. The construction of this gate-house was, however, delayed until the early part of the month of March on account of a very severe blizzard during the latter part of February.

FEEDER CANAL.

Plate XXII indicates some of the difficulties to be encountered in the construction of a high-level canal by which the water is to be delivered to this reservoir from the Gallinas River. The line across the face of the photograph indicates the approximate location of the canal. There are a number of such cliffs along the line selected for the canal, and at each a box flume will be constructed and supported on wrought iron brackets on the face of the cliff. The flume will be built out gradually from bracket to bracket, the holes for each bracket being drilled from a stage supported as a cantilever from the two brackets next preceding. This affords an inexpensive construction and although it may become damaged from time to time by falling rocks from the overhanging cliffs, it is anticipated that repairs can be easily made.

PAINT FOR STANDPIPES, AND METHODS OF APPLYING.

TOPICAL DISCUSSION.

(November 13, December 11, 1912.)

Mr. George A. Stacy.* Mr. President, this is one of the little things pertaining to water works that we are hunting for information on. We depend entirely upon hydrant service, as we have no steamers, so we erected a standpipe, with an independent line of mains and hydrants, for the higher level of the city. As this standpipe is used for fire service only we did not have to be so particular in regard to the paint which was put on the inside, as to its communicating taste or odor to the water. The standpipe was built in 1895, and the specifications called for two coats of the best asphaltum paint that we could hear of at that time. I thought as I looked at it, after it was on, that it would be almost as permanent as enamel and would be a thorough protection to the wrought iron.

In about three years I noticed that it looked as though the paint was all gone. We drew the water off, and even with the microscope you could not detect that there had ever been any paint on the tank in any way, shape or manner, not even in the joints or around the rivets, or anywhere else. I do not know how long the tank had been in that condition, for I had such confidence in the paint that I had never thoroughly examined it. The water was not used for our domestic supply so the fluctuation of water level in the tank was very slight, five feet was the maximum in the winter, when we keep it from freezing by artificial circulation, and one or two feet in the summer.

In repainting we got some paint which was highly recommended, some discovery which they claimed made this paint particularly adapted for this kind of work. We had looked around but couldn't find any reliable data which we could go by as to paint that anybody else had used, so we put that on. This did a little better, but at the end of three years was gone. Then we tried something else which had been recently discovered and which had come into use to a certain extent at that time for coating steel pipe. We put that on, and I watched it as time went along, and we found that near the water line, or the ice line, where the ice broke as the water rose and fell in the tank, the ice would break away from the side, and it seemed to affect the paint there more than anywhere else; at the end of three years we emptied the tank to see its condition. We found the paint which was purported to be very elastic and very tough hanging on the sides of the tank in places like loose paper on the wall. There would be a strip attached to the top and hanging loose, and then some few feet off another, and some of it you could pull off. It certainly was tough, but it did not adhere to the iron, so that it was no protection to what was behind it.

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* Superintendent Water Works, Marlboro, Mass.

I thought, perhaps, that that was due to some imperfection in preparing the tank. I thought the matter over, but I did not see how we could do any better than we had, because the iron was perfectly clean, and there was no question about its being dry, because it was so hot in there when the sun shone that it was very uncomfortable, and when the water was drawn out it didn't take but a little time for the tank to dry, so I laid it to the paint.

This carries us along quite a period, and then we tried a paint which was made of different material. We put that on a few years ago, — I guess it has been painted once since, — and that stayed on about three years and a half or four years, and when we drew the tank off to paint it again it was in the best condition that it ever had been. The paint on the bottom was almost perfect. I thought then we had found what we were seeking, that is, something which had durability and which would last three years and remain effective. So I got the same paint, as I supposed, and applied it again; and in three or four years we drew the tank down and this time it looked a good deal as it did the first time we painted it. I could not detect that there was any paint left. It was bought from the same party and supposed to be manufactured by the same concern; we paid the same money for it, and I knew that the tank was prepared in the same way as before.

The next time I made a complete shift. I got some red lead, had it ground for me, and painted the inside of the tank with that, and put two coats of other paint outside of it, and in the future, if I live, I will tell you how that comes out.

I am satisfied of this: that up to the present time — and I may be showing considerable ignorance in this matter — I have not yet been able to learn of a paint that will thoroughly protect the inside of a standpipe for a term of three years, so that it will be in good condition at the end of that time. If there is such a paint I should like to know what it is and who makes it.

Of course some of the paint we used would not be put on a tank from which the water was used for domestic purposes. I mentioned what our tank was used for, so you would know that I wasn't hampered in painting it for fear of anything which would cause taste or odor. This is as far as I have got, and I don't think I know a great deal more about it than I did in 1895, when the tank was constructed, and if anybody can give me any information it would be a great favor.

Mr. Frank L. Fuller. I should like to ask Mr. Stacy how many coats of paint he put on.

Mr. Stacy. We put on three, two outside of the red lead.

Mr. Fuller. Will one coat over a coat of red lead cover it, or does it need two coats? For instance, suppose you are putting it on the outside of a tank and have a first coat of red lead, would a second coat of some tint, lead and oil, cover it?

Mr. Stacy. I will say, Mr. Fuller, that that is the reason we put on the third coat. The first coat we put on over the red lead did not thoroughly cover it. On the outside of the tank we haven't had any trouble in finding paint that I consider satisfactory in every way, and would protect the tank thoroughly as long as you would expect anything of that kind to last, say five or six years.

Mr. Fuller. What kind of paint did you use on the outside?

Mr. Stacy. I used a mineral paint, made, I think, by some people in Cincinnati; I can't tell you just the address now. It was about five years ago that we painted the outside last. We painted it with two tints, — it comes in colors, — and it has given satisfaction. But when we come to the inside of the tank it has been a perfect failure as far as finding anything which was satisfactory.

MR. HARRY L. THOMAS. Will Mr. Stacy kindly tell us how he prepared the inside of his standpipe. Did he do anything more than brush it before painting?

MR. STACY. It was thoroughly scraped down to the iron. We didn't use any sand blast, but we used chisels, hammers, steel scrapers, and brushes. It was the hardest work to remove the rust around the rivets and around the seams.

MR. GEORGE E. WINSLOW. I would like to ask Mr. Stacy if he has ever tried pure beeswax for a paint.

MR. STACY. No; that is something new. I will try it next time.

MR. WINSLOW. I have never used it for painting a standpipe, but I have used it on iron work, on cast iron and on copper and tin, and I have found that it is the best of anything I have been able to get for paint. Perhaps you know that they use it on the iron patterns that are used in foundries, and it keeps the rust off perfectly. Beeswax is not affected by water or, in fact, by any liquid, I don't care what it is. But when you put it on iron you don't want to paint it on and leave it as paint is left. You have to warm the iron and put it on in a very thin coat indeed. In other words, to paint the inside of a standpipe, which I have never done, you would apply it hot with a brush, and then take a blow-torch and warm the iron and let all of it flow off that will. I have found that it works very well on cast iron, and the rust does not attack it.

MR. STACY. I will say, Mr. Winslow, that you wouldn't have to use any blow-torch on the sunny side of our tank. The only trouble would be to keep the beeswax from all flowing off down to the bottom.

MR. WINSLOW. No; it wouldn't do that.

MR. STACY. You can't bear your hand on the tank where the sun strikes it on a bright day.

Mr. Winslow. The beeswax wants to be very thin indeed. You put it on with a brush and put it on hot and as thin as you can, and it will peel even then. But when all has flowed off that can flow off it will leave a coating that will not peel. You put it in a cup, or anything you choose, and let it harden, and you will find a joint between the beeswax and the cup; but by putting it on very thin it works very nicely on my work. I can't say anything about it for use on the outside of a tank, but on the inside, where it is covered with water, there isn't any possibility that it will flake off, if it is put on in the way I suggest. I won't say that it is the thing to use; I merely asked if you had ever tried it; this is only a suggestion.

Mr. Robert S. Weston.* In painting standpipes the metal is fully as important as the paint applied to it. Most of us are pretty well agreed that if we get iron which is free from mill-scale it will stand longer, take the paint better, and the rust beneath the paint will be less apt to push the paint off than if the ordinary metal is used.

Recently I made an experiment with a tank used to hold a ground water containing an excessive amount of carbonic acid. The metal is a new material called "ingot" iron, which is supposed to be a very pure iron made by the steel process. It is practically steel which has been heated in an open-hearth furnace until all the manganese has been burned out of it, or an open-hearth steel treated with heat until it is homogeneous in character. I painted this tank with two coats of a pitch and linseed oil paint and thought that I was going to get conditions which would stand corrosion very well, but after several months' use the water began to corrode the metal and I think I am going to have about the same experience that Mr. Stacy has had.

There is no paint which cannot be criticised, but it is also true that if the mill-scale be removed from plates, paint will stick to the metal very much better. I believe that the modern practice of sand blasting the plates before painting is one of the best steps which has been taken to secure good coatings on the insides of standpipes.

Professor Whipple's experiments at Harvard have shown that the plates which are most readily attacked by water are those which have the most mill-scale on them, and as long as plates are covered with scale it doesn't seem to make much difference whether the metal is iron, steel, ingot iron, or any other iron alloy, provided the metal is fairly good in quality. When the scale has corroded away, the purer and more homogenous iron is the better, but the advantages of a good steel, free from scale, greatly exceed those of the higher priced, purer iron, with the scale on.

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* Consulting Sanitary Engineer, Boston, Mass.

Dr. Cushman, who has done a great deal of work for the Department of Agriculture in getting out specifications for fence wire and other agricultural iron, has advised a paint whose pigment is boiled in potassium bichromate before being ground with the oil. He claims that this treatment of the pigment neutralizes the electrolytic action of the water on the metal. These paints can be procured, I believe, of a Philadelphia manufacturer, but I do not think they have been used long enough to determine how much better they are than the ordinary paints.

Theoretical considerations and experience lead me to believe that the thing to do is to put the paint on clean, dry metal as the first requisite; second, use a paint which contains materials which are elastic and quite insoluble in water. The three types of paint usually used are:

First, pitch or bitumens dissolved in boiled linseed oil;

Second, furnace paints; and

Third, linseed oil paints.

I have tried all of them, but am not in a position to say that any one has the advantage. Pitch paints are a little more liable to contain materials which will dissolve in water. On the other hand, they are the most elastic. Of the pigment paints, those which contain some zinc and a filler like asbestos fiber are a little more durable than those made of pure pigment and pure oil. These latter are liable to disintegrate.

MR. DEXTER BRACKETT.* Mr. President, I will offer a few notes on the subject, which may be worthy of a place in your records. Our experience on the Metropolitan Water Works indicates that red-lead paint applied to the interior of standpipes is one of the best, if not the best, protection against rusting. The paint now used is mixed in the proportion of three gallons of boiled linseed oil to 100 lb. of the best quality of red lead, to which is added 2½ lb. of litharge thoroughly beaten up with the linseed oil. This is the formula used by the United States Navy for paint used on the bottoms of ships. The litharge causes the paint to dry quickly and also hardens it.

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*Chief Engineer, Metropolitan Water Works, Boston, Mass.

The standpipe on Forbes Hill in Quincy, 30 ft. in diameter and 64 ft. 3 in. high, was painted in 1902 at a cost of $427. The interior was first thoroughly cleaned of rust and loose paint by the use of putty knives and wire brushes. One coat of red lead mixed with raw linseed oil and a little turpentine was then applied, and over this were applied two coats of Gilsonite paint, made by the Commercial Asphalt Company, of New York. The exterior was given two coats of white lead and linseed oil, tinted a light gray color. This standpipe is enclosed in a granite masonry tower and covered so that ice does not form to such an extent as it would if the standpipe were exposed directly to the weather. The interior of the standpipe has not required repainting until the present season. The interior of the standpipe has recently been given three coats of red lead, United States Government specification, with no covering of Gilsonite, and the exterior one coat of white lead and oil, at a total cost of $430.

We have a standpipe in Arlington, 40 ft. in diameter and 60 ft. high, with a conical steel roof and exterior spiral stairway, all exposed to the weather. The water pumped into both this and the Forbes Hill standpipe has a temperature of from 38 to 40 degrees during the winter, and ice forms in this standpipe to a greater extent than in standpipes supplied with water drawn from ground water supplies, which does not ordinarily fall below 50 degrees.

This standpipe was painted in 1906 at a cost of $425. The interior, after being thoroughly cleaned, was given one coat of red lead and two coats of Gilsonite. The roof trusses and under side of the roof were given two coats of red lead and oil, and the exterior of the standpipe and roof one coat of white lead and oil. In 1911 this standpipe was emptied and both exterior and interior repainted in the same manner as in 1906, at a cost of $475.

Mr. C. E. Peirce. I would like to ask the gentleman what preparation he makes for painting.

Mr. Brackett. Thoroughly clean the iron. That is really the best thing which can be done. We have not used sand blasting, but we have thoroughly cleaned the iron by the use of wire brushes and scraping.

PROCEEDINGS.

NOVEMBER MEETING.

HOTEL BRUNSWICK,
BOSTON, MASS., November 13, 1912.

Mr. George W. Batchelder, the President, presiding.
The following members and guests were present:

HONORARY MEMBERS.

Desmond FitzGerald, Henry C. Meyer, and Frederic P. Stearns. — 3.

MEMBERS.

S. A. Agnew, C. H. Baldwin, A. F. Ballou, L. M. Bancroft, F. A. Barbour, H. K. Barrows, G. W. Batchelder, A. E. Blackmer, J. W. Blackmer, C. A. Bogardus, E. C. Brooks, G. A. Carpenter, C. E. Chandler, J. C. Chase, R. D. Chase, E. A. Clark, R. C. P. Coggeshall, W. R. Conard, A. W. Cuddeback, J. A. Cushman, E. D. Eldredge, G. F. Evans, F. L. Fuller, A. S. Glover, Clarence Goldsmith, J. M. Goodell, X. H. Goodnough, R. A. Hale, R. K. Hale, F. E. Hall, T. G. Hazard, Jr., D. A. Heffernan, M. F. Hicks, Willard Kent, G. A. Kimball, G. A. King, J. J. Kirkpatrick, C. A. Leary, N. A. McMillen, A. E. Martin, F. E. Merrill, Leonard Metcalf, H. A. Miller, J. H. Mendall, William Naylor, G. A. Nelson, F. L. Northrop, H. E. Perry, A. L. Sawyer, J. E. Sheldon, G. H. Snell, G. A. Stacy, W. F. Sullivan, H. A. Symonds, H. L. Thomas, R. J. Thomas, J. L. Tighe, E. J. Titcomb, D. N. Tower, C. H. Tuttle, W. H. Vaughn, R. S. Weston, F. B. Wilkins, F. I. Winslow, and G. E. Winslow. — 65.

ASSOCIATES.

H. L. Bond & Co., by F. M. Bates; Builders Iron Foundry Company, by A. B. Coulters and G. H. Lewis; Chapman Valve Manufacturing Company, by H. L. DeWolf; Hersey Manufacturing Company, by Albert S. Glover; Lead Lined Iron Pipe Company, by T. E. Dwyer; Charles Millar & Son Company, by C. F. Glavin; H. Mueller Manufacturing Company, by G. A. Caldwell; National Meter Company, by C. H. Baldwin and J. G. Lufkin; Pittsburg Meter Company, by J. W. Turner; Rensselaer Manufacturing Company, by F. S. Bates and C. L. Brown; Ross Valve Manufacturing Company, by William Ross; Pratt & Cady, by C. E. Pratt; A. P. Smith Manufacturing

Company, by F. L. Northrop; Thomson Meter Company, by S. D. Higley, W. S. Cetti, and E. M. Shedd; Union Water Meter Company, by F. E. Hall and E. K. Otis; Water Works Equipment Company, by W. H. Van Winkle, Jr.; R. D. Wood & Co., by H. M. Simons; Henry R. Worthington, by Samuel Harrison. — 24.

GUESTS.

F. W. Tucker, W. D. Cashin, Boston, Mass.; J. P. Wood, inspector, Marlboro, Mass.; Frank I. Hamlin, water commissioner, Haverhill, Mass., D. W. Agnew, Scituate, Mass.; Ivers M. Low, superintendent water works; Weymouth, Mass.; and Mr. E. M. Nichols, Philadelphia, Pa. — 7.

The records of the last meeting of the Association were read by the Secretary and adopted.

Applications for membership were submitted by the Secretary from Henry Manley, Jr., Boston, Mass., engaged as assistant in general engineering practice; and Luther W. Burt, Hartford, Conn., active and consulting engineer. On motion of Mr. Frank L. Fuller, the Secretary was empowered to cast one ballot in favor of the applicants, and, he having done so, they were declared elected members of the Association.

Mr. Frederic I. Winslow, engineer of extension, Public Works Department, Water Service, Boston, presented an illustrated paper on "Some Difficulties Encountered in Tunnel and Subway Construction."

Mr. Desmond FitzGerald gave an entertaining description of a trip "From Italy to the China Sea," illustrated by a series of beautiful stereopticon pictures. Before beginning his remarks he expressed his great pleasure at meeting with the members of the Association once more, and finding so many of his old friends in attendance. He was cordially welcomed, and, at the close of his talk, the President on behalf of the members thanked him for the great treat he had given them.

Mr. George A. Stacy opened the topical discussion, the subject being "Paint for Standpipes, and Methods of Applying." The discussion was further participated in by Mr. Frank L. Fuller, Mr. Harry L. Thomas, Mr. George E. Winslow, and Mr. Robert S. Weston.

Adjourned.

DECEMBER MEETING.

HOTEL BRUNSWICK,
BOSTON, MASS., December 11, 1912.

President George W. Batchelder in the chair.

The following members and guests were present:

HONORARY MEMBER.

F. P. Stearns.

MEMBERS.

S. A. Agnew, C. H. Baldwin, A. F. Ballou, L. M. Bancroft, W. T. Barnes, G. W. Batchelder, A. E. Blackmer, J. W. Blackmer, George Bowers, Dexter Brackett, E. C. Brooks, E. W. Bush, W. L. Butcher, F. H. Carter, J. C. Chase, R. C. P. Coggeshall, W. R. Conard, H. R. Cooper, J. A. Cushman, John Doyle, E. D. Eldredge, T. C. Gleason, A. S. Glover, F. H. Gunther, R. A. Hale, R. K. Hale, F. E. Hall, L. M. Hastings, T. G. Hazard, Jr., J. L. Hyde, Willard Kent, G. A. King, F. A. McInnes, N. A. McMillen, H. V. Macksey, F. A. Marston, A. E. Martin, John Mayo, F. E. Merrill, William Naylor, C. E. Pierce, T. A. Pierce, J. L. Rice, G. A. Sampson, P. R. Sanders, A. L. Sawyer, C. W. Saxe, J. W. Smith, G. H. Snell, W. F. Sullivan, E. S. Tucker, C. H. Tuttle, W. H. Vaughn, F. P. Washburn, R. S. Weston, F. B. Wilkins, F. I. Winslow, G. E. Winslow, I. S. Wood, F. L. Northrop. — 60.

ASSOCIATES.

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The records of the November meeting were read by the Secretary and approved.

Applications for active membership, properly endorsed and recommended by the Executive Committee, were presented by the Secretary from Herbert R. Horton, East Providence, R. I., superintendent of Watchemaket Fire District; G. O. House, St. Paul, Minn., general superintendent St. Paul Water Department; Alvin C. Howes, Middleboro, Mass., superintendent Middleboro Water Works; D. McD. Campbell, Sydney, N. S., city engineer of Sydney.

On motion of Mr. Thomas A. Pierce, the Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared duly elected members of the Association.

Mr. Gilbert H. Pratt, chemist of the Rhode Island State Board of Health, read a paper entitled "Uses and Abuses of Water Filtration." Mr. Charles W. Saxe spoke briefly in regard to the filtration plant at Newport, R. I.

Mr. William T. Barnes, civil engineer, Chicago, Ill., gave a description of the Las Vegas dam, illustrated by stereopticon views.

The subject of "Paint for Standpipes, and Methods of Applying," which was discussed at the November meeting, was again taken up and discussed by Mr. Dexter Brackett.

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, November 13, 1912, at 11.30 A.M.

Present: President George W. Batchelder, and members Millard F. Hicks, Robert Spurr Weston, George A. Stacy, Lewis M. Bancroft, Richard K. Hale, George A. King, and Willard Kent.

Two applications for membership were received and recommended for admission, namely: Henry Manley, Jr., civil engineer, Boston, Mass.; and Luther W. Burt, civil engineer, Hartford, Conn.

It was *voted:* That three former members of the Association, dropped for non-payment of dues on June 10, 1912, having since said date remitted their dues, be, and they are hereby, restored to membership in the Association.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Wednesday, December 11, 1912, at 11.30 A.M.

Present, President George W. Batchelder and members J. Waldo Smith, Robert Spurr Weston, Lewis M. Bancroft, Richard K. Hale, George A. King, and Willard Kent.

Four applications were received and recommended for membership, namely:

For members: Herbert R. Horton, superintendent Watchemaket Fire District, East Providence, R. I.; G. O. House, general superintendent St. Paul Water Department, St. Paul, Minn.; Alvin C. Howes, superintendent Middleboro Water Works, Middleboro, Mass.; D. McD. Campbell, city engineer, Sydney, N. S.

One former member, dropped from the rolls for non-payment of dues, having paid same in full, was by vote reinstated.

Adjourned.

WILLARD KENT, *Secretary.*

OBITUARY.

GEORGE ALBERT KIMBALL.

Died December 3, 1912.

GEORGE ALBERT KIMBALL was born in Littleton, Mass., May 14, 1850, the son of William and Mary (Lawrence) Kimball. He received his early education in the schools of Littleton and, later, at Appleton Academy, New Ipswich, N. H., where he prepared for Dartmouth College. Owing, however, to serious trouble with his eyes he was obliged to give up his college course.

In 1869 he took up the study of civil engineering in the office of Frost Brothers, of which firm he later became a partner, where he remained until 1874, when he opened an office in Somerville. From 1876 to 1887 he was city engineer of Somerville. During that time he was also chairman of the city board of health, an alderman, and member of the water board. In 1887 he opened an office in Boston for the practice of engineering. In 1888 he was appointed a member of the Grade Crossing Commission, and in 1896 a member of the Metropolitan Sewerage Commission. In 1896 he was made chief engineer of the Boston Elevated Railway Company, in which capacity he was responsible for the design and construction of all the elevated and subway work. Mr. Kimball during these years made a specialty of the construction of sewers and water works and had collected a valuable library on these subjects covering many New England cities and towns.

In 1872 Mr. Kimball married Elizabeth Emily Robbins, of New Ipswich, N. H., who with four children survives him. He died of heart failure at his home in Arlington, December 3, 1912.

Mr. Kimball was a director of the American Society of Civil Engineers, a past president of the Boston Society of Civil Engineers, a member of the Institute of Civil Engineers and of the American Institute of Consulting Engineers. He was also a member of many clubs and fraternal orders. He was elected a member of the New England Water Works Association on June 17, 1887.

BOOK REVIEW.

A TREATISE ON HYDRAULICS. By Mansfield Merriman. Ninth edition, revised and reset, with the assistance of Thaddeus Merriman. 8vo, x+565 pages, 224 figures. New York: John Wiley & Sons. Cloth, $4.00 net.

This book is so well known to all students of hydraulics that an extended review is unnecessary. The first edition was published in 1889 and it has been reprinted and enlarged many times since. In 1903 it was rewritten and enlarged (eighth edition), and many new features were added to it when reprinted. The present edition (ninth) has been entirely revised and reset in order to present more logically the previous additions and to include more fully the advances of the last decade. The chief additions are chapters on hydraulic instruments and observations, and pumps and pumping, but much new material has been added to other chapters. As in previous editions many of the formulæ and tables are repeated with metric units, and an interesting but brief history of hydraulics is included.

Although primarily intended for the use of students in technical schools, it is an excellent reference book for practicing engineers, and will be of great value to any one who has to solve hydraulic problems; but the writer noticed few of the tables and none of the diagrams so useful for the solution of everyday problems in the office.

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OF THE

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ISSUED QUARTERLY.

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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **700** men. Its membership is divided into two principal classes, viz.: Members and Associates. Members are divided into two classes, viz.: Resident and Non-Resident, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The Initiation fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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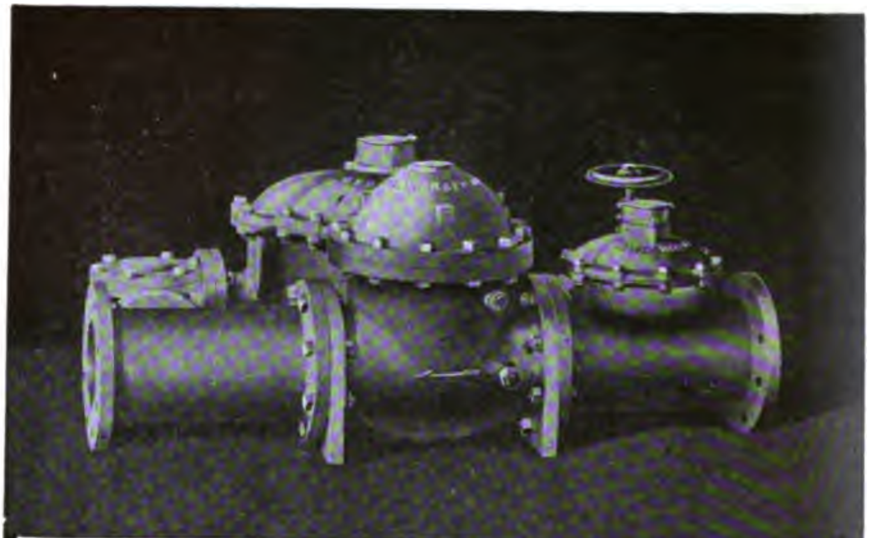

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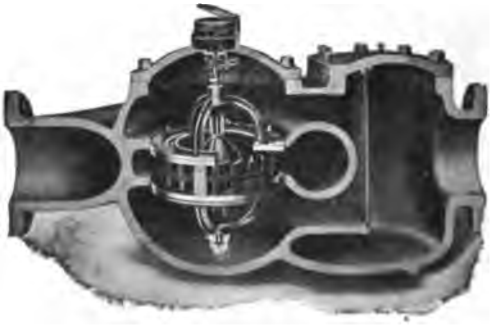

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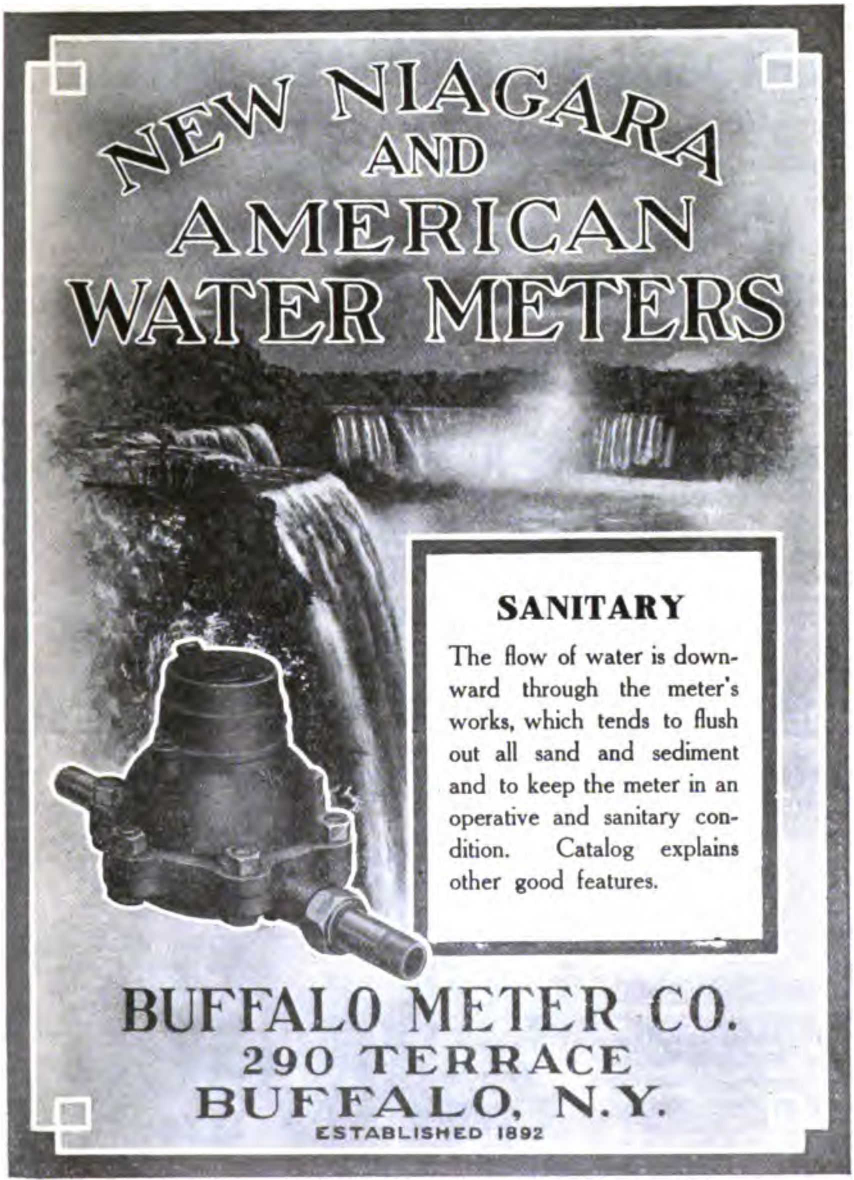

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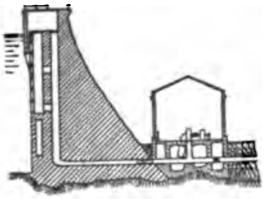

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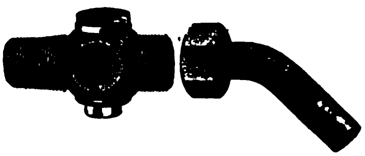

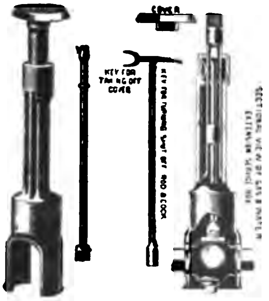

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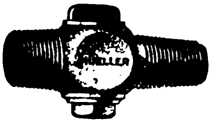

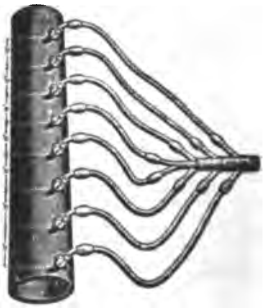

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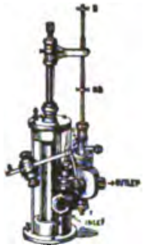

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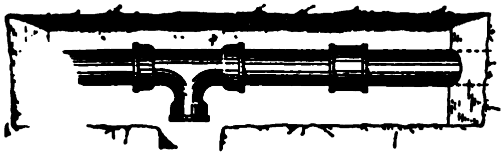

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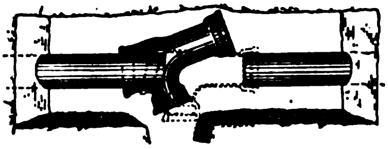

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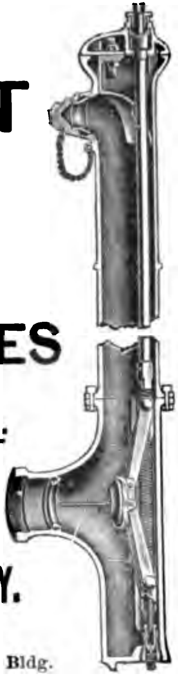

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